Annexure A

Proposed WOAN model

1 Executive summary

1.1 Telkom supports the creation of a viable wireless open access network (WOAN) in South Africa. South Africa's broadband penetration remains poor[1] and access to broadband expensive. Furthermore, duplicated infrastructure leads to higher network costs and higher priced services, which contribute to broadband remaining unaffordable for a large portion of the South African population. The mobile broadband market in South Africa is effectively a duopoly between the dominant operators, Vodacom and MTN, and the WOAN will contribute towards a more competitive retail market.

1.2 Telkom is of the view that a WOAN is necessary to level the playing field in mobile communications and increase competition by allowing new players to enter the market. A WOAN will be the most economically compelling approach to mobile network operators (MNOs) for meeting future demand, subject thereto that all unassigned high demand spectrum (HDS) is assigned to the WOAN and that the WOAN has spectrum in both the low bands (for rural coverage, in building penetration) and higher bands (for capacity). By extending mobile broadband access to unserved and poorly served regions and enhancing broadband competition, it will further bring down price.

1.3 Telkom supports the establishment of a WOAN which is both technically and economically feasible. This submission sets out a high level WOAN construct, drawing from international experience, which meets these requirements and which is capable of being practically and viably implemented in South Africa. The WOAN can provide substantial remote area coverage which minimises the extent of new network build required in unprofitable remote areas. The WOAN can further lower the costs of providing network infrastructure for providers.

1.4 There are certain critical success factors to ensure the sustainability of the WOAN. For the WOAN to be technically feasible, it must have access to spectrum, be minimally prescriptive re technology, be deployed in three distinct phases and have flexible service offerings and accommodate different types of customers.

[1] See note 1 above.

1.4.1 With regards to spectrum, all currently unassigned HDS must be assigned to the WOAN. In order to establish nationwide coverage by means of low band spectrum capable of good reach in rural areas, the WOAN must have access to a significant quantity of low band (below 1GHz) spectrum in order to achieve coverage objectives, as coverage into currently unserved or underserved areas is most cost effectively accomplished by sub-1GHz bands. An example of the assignment of low band spectrum to the WOAN is the Red Compartida in Mexico, which will be discussed in section 4.1.1 below. The WOAN should further have sufficient spectrum in high bands to meet capacity objectives. A full argument supporting the assignment of all spectrum to the WOAN is set out in the report by Econex, attached as annexure B to Telkom's main submission.

1.4.2 The more spectrum made available, the greater the number of subscribers who can be served from a relevant cell with a reasonable broadband data rate. Fewer cells are then required, which significantly improves the cost effectiveness of the network deployment.

1.4.3 The WOAN must be minimally prescriptive re technology. This is so that it can adapt to changes in technology. For example, 5G spectrum will enable a higher spectral efficiency than LTE. The deployed infrastructure should therefore be LTE/5G flexible. The network should further allow for various device capabilities and be able to accommodate new devices. The WOAN should not be constrained to non-optimal technology choices.

1.4.4 The WOAN should be rolled out in urban and rural areas to achieve nationwide LTE/5G coverage. It should further have mandated open access to existing MNO infrastructure at incremental cost based prices as well as access to state-owned assets (e.g. public buildings, infrastructure, etc.) and enjoy cost-based interconnect/termination and roaming. While a great deal of population coverage with broadband capacity can be achieved in the lower band spectrum, a better broadband experience will also require the build-out of more sites. The optimal way to achieve maximum coverage for the WOAN is by means of a three phased approach.

1.4.4.1 The initial phase of deployment (Phase 1) should rely on existing infrastructure such as fixed radio infrastructure through antenna sharing as well as the

addition of the antennas, baseband equipment and backhaul. More profitable urban cells should make for less profitable rural cells. Provision should be made for fast-tracking approvals to leverage the assets of current providers.

1.4.4.2 Phase 2 of the deployment should aim at identifying coverage gaps and filling them. It may require network build in rural areas and the approach should be subsidisation by government through conditional grants or a digital dividend fund in areas which would otherwise not be economically attractive for Phase 2 deployment.

1.4.4.3 Phase 3 should focus on capacity augmentation. This may require including new carriers, cell site splitting, new radios in new spectral bands etc. As this would be geographically targeted, it may require similar subsidisation as during Phase 2.

1.4.5 The WOAN should further have appropriate wholesale service offerings available for sale to various operators. These are Radio Access Network (RAN) sharing, Multi-Operator Core Network (MOCN) sharing and Mobile Virtual Network Enabler (MVNE) services, as discussed in paragraph 4.1.4 below. The services should offer reliability, availability, security, resilience and service restoration capability. The WOAN should support applications such as voice, streaming video, file transfer, public protection and disaster recovery.

1.5 In order to be commercially feasible, the WOAN should be offered various incentives to attract private investors, as set out below.

1.5.1 The WOAN must have a fast start – a slow roll-out will allow operators to claim that the WOAN is not a viable approach and to explore other alternatives to satisfy demand.

1.5.2 The WOAN should be a private sector led partnership structured as a privately designed, built and operated (PDBO) network. Telkom is of the view that a privately designed, built and operated WOAN is the best model, as the demand for services offered by the WOAN will be sufficient to attract investment by the private sector. Additional financial support may however be required at the early stages of the WOAN in the form of public funds in order to create an acceptable case for investment. However, the incumbent MNOs should not have a controlling stake in the WOAN.

Government's involvement should only be through providing support and certain guarantees. For faster rollout, the WOAN can be structured as regional WOANs with regional and national points of interconnect (POIs).

1.5.3 The WOAN may best be organised to support regionally-based wholesale services, allowing for economic participation directly linked to communities, satisfy the unique geographies and service needs of the region and develop relationship with regional structures to facilitate roll-out eg wayleaves. Regional groups may further contribute to investment.

1.5.4 The WOAN must have access to sufficient capital and if operated by an existing network operator of a division thereof, that operator must have complete wholesale v retail separation.

1.5.5 There must be a concession period of 20 years within which the WOAN model is not substantially changed e.g. in respect of spectrum rights.

1.5.6 All unassigned HDS spectrum must be assigned to the WOAN. A spectrum auction will entrench the dominance of the current duopoly and negatively affect competition in the market, as the dominant MNOs are likely to outbid competitors in order to obtain spectrum. Spectrum needs to be assigned to the WOAN so that MNOs must get access to new capacity via the WOAN, supporting its economic feasibility.

1.5.7 The WOAN should only sell wholesale services and must not be managed by a retail operators, as was the case in Russia. Despite the interest in a WOAN deployment in Russia, the initiative stopped. Apart from the opposition by the MNOs, the project was flawed by the fact that the proposed wholesaler was an existing MNO that would keep retailing activities. Retailers (MNOs) will not voluntarily purchase from a wholesaler whom they perceive as a direct competitor

1.5.8 It must have open access to critical MNO infrastructure in order to support low-cost deployment. This includes the sharing of high sites, masts, antennas etc.

1.5.9 It must be flexible with regards to pricing. The WOAN must provide wholesale capacity at and nationwide coverage at a lower cost that if MNOs would have achieved if they had been allocated additional spectrum. The WOAN should be able to set prices differentiated by geography, performance or quality criteria.

1.5.10 The WOAN must be able to obtain additional spectrum to cope with growth.

1.5.11 The WOAN should be autonomously operated and there should be an independent regulatory oversight group to measure coverage, performance, availability, and whether the WOAN is meeting its objectives. It should also be able to resolve disputes.

1.5.12 Government customers should be anchor customers of the WOAN and the WOAN may at its discretion require retail service providers to contract capacity for some region or minimum breadth of geographic coverage.

1.5.13 A revenue cap may be set for WOAN services to ensure it covers its costs plus ROI or a maximum ROI can be set. Excess profits can then be used for investment.

1.5.14 The WOAN must be pro-competition and be able to reserve some capacity for non-facilities based retail operators should there be a threat that all available capacity be booked up.

1.5.15 Regulation of availability and incremental cost-based pricing of open access infrastructure is recommended, specifically for interconnection, roaming and traffic termination.

The above factors will be further unpacked in this submission.

2 Why a WOAN is imperative for South Africa

2.1 The behaviour of individual profit-seeking firms does not always result in optimal outcomes for society as a whole. The desire for different outcomes supports the argument for a WOAN in South Africa: if the existing market structure has not produced the desired outcomes, then the structure needs to be changed. As set out in the South Africa Connect Broadband Policy published on 6 December 2013 (SA Connect),[2] mobile broadband has become the primary form of broadband access in South Africa. There are almost 40 times as many mobile data

[2] SA Connect: South Africa's Broadband Policy, 23 November 2016

subscribers as fixed line broadband connections (DSL and fibre combined).[3] Data from 2015 indicates that 47.6% of the population used mobile devices to access the Internet.[4] The mobile broadband market is effectively a duopoly between the dominant operators, Vodacom and MTN, who together have ~80%[5] of all subscribers. Notwithstanding this, South Africa's broadband penetration remains poor[6] and access to broadband expensive.

2.2 As at January 2017,[7] MTN and Vodacom have more than twice as many base stations as Cell C, who in turn has more than twice as many base stations as Telkom Mobile.[8] Smaller operators such as Telkom Mobile may find it difficult to access MTN and Vodacom's high site infrastructure under existing infrastructure sharing rules, resulting in additional network build. Duplicated infrastructure leads to higher network costs and higher priced services, which contributes to broadband remaining unaffordable for a large portion of the South African population. The welfare of South Africa will therefore be optimised by regulation that enables sharing of mobile network assets.

2.3 The principal objectives of a WOAN in South Africa are to enhance broadband competition in order to bring down price (economic affordability), extend wireless broadband access to unserved and poorly served regions (geographic availability), ensure economic participation by historically disadvantaged persons and promote economic growth fuelled by lower prices and improved capacity and performance. [9] SA Connect set the stretch objective that 100% of

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[3] UBS Global Research Report: "South African Telecoms Evidence Lab: SA Fibre Picture moving into focus, outlook tougher for Telkom", 23 Feb, 2017

[4] ICASA, "Report on the state of the ICT sector in South Africa", 31 March 2017

[5] June 2016 https://www.fin24.com/Tech/Companies/telkom-mobile-to-fight-for-its-share-20161118

[6] See note 1 above.

[7] TeleGeography GlobalComms Database South Africa, pg 23-26.

[8] TeleGeography, Op. Cit. Vodacom has roughly 11,000 sites, of which almost all support 2G (GSM) at 900MHz and 3G (WCDMA) at 2100 Mhz. About 4000 sites support LTE or LTE-A at 1800MHz. MTN has roughly the same number of sites as Vodacom, supporting 2G (GSM/GPRS/EDGE) at 900MHz, WCDMA at 2100MHz. A much smaller number of sites (<2400) support LTE or LTE-A at 1800MHz. Cell C has about 4600 cell sites, of which most support 2G (GSM/GPRS/EDGE) at 900/1800MHz, and most support 3G (WCDMA). Major urban center sites support LTE/LTE-A at 2100MHz. Telkom Mobile South Africa has 2G/3G coverage via roaming agreement with MTN, and approximately 1500 sites supporting TD LTE/LTE-A at 2300MHz or LTE at 1800MHz. iBurst has a very small number of sites (~240) in urban centers supporting TD-LTE-A at 1800/2600MHz.

[9] South Africa Connect (n 1 above); National Integrated ICT Policy White Paper, 2016; Electronic Communications Amendment Bill, 2017.

South Africans should have access to broadband services at defined throughput speeds costing 2.5% or less of the population's average monthly income.[10]

2.4 Affordability becomes compounded with geography in that the most expensive areas to cover are low density rural areas with a larger portion of the population at lower income levels with the least ability to pay. The WOAN can provide substantial remote area coverage which minimises the extent of new network build required in unprofitable remote areas. The WOAN can further lower the cost structure of network infrastructure for providers. This could be based on the free assignment to the WOAN of high demand spectrum, avoidance of network duplication and making low-cost infrastructure available on an open access basis, thereby encouraging vigorous retail competition and bringing down prices. In addition, the WOAN can share costs across multiple retail customers.

2.5 Moreover, because of the potential spectrum crunch in urban regions, the WOAN will be the most economically compelling approach to MNOs for meeting future demand, providing the WOAN has spectrum both in the low bands (for in building penetration) and higher bands for capacity. The other options available to these operators to achieve urban capacity densification will generally be quite expensive.[11] MVNOs will find the WOAN desirable for both urban and rural cases; the maximum competitive price point for the WOAN would be defined by the price points at which the existing MNOs such as Cell C offer MVNO capacity to retail operators, which globally is generally in the 40-60% range below retail subscriber prices. In this regard, achieving sufficient utilisation of the WOAN is critical not only to assure a financial return that will attract private capital, but also to achieve economies of scale that make the WOAN's cost structure competitive.

2.6 Access to spectrum is further key to improving wireless broadband capacity and performance and can assist with minimising network costs. South Africa, while doing well relative to Africa's poorest countries, does not have globally competitive mobile broadband connection speeds, and is not even a leader in Africa, with an average connection speed for mobile connections

[10] SA Connect, Op. Cit. Section 1

[11] Some of these proposed solutions may not have adequate quality of service (Wifi, LAA, LTE-U; unlicenced bands) or not have good device support. See comment from VDC CTO: https://mybroadband.co.za/news/cellular/223584-how-vodacom-builds-its-network-when-government-blocks-capacity-increases.html)

of 6.9Mbit/s vs 12.2 Mbit/s for Egypt and 13.7Mbit/s for Kenya.[12] Globally, South Africa is 55th of 74 countries evaluated, behind such countries as Chile, Peru, Indonesia, Philippines, Thailand, Croatia, Lithuania, and Slovenia.[13] Since South Africa has such low fixed broadband penetration, the performance of mobile broadband becomes that much more critical. Performance of mobile broadband is a function of the technology (eg. LTE vs 3G), spectral width, cell size, and other factors. The 3G population coverage is broad ~99% as of Dec 2016[14], but LTE coverage more limited, ~75% as of May 2017 for Vodacom, which claims the largest coverage.[15]

2.7 With regards to the assignment of spectrum, a spectrum auction will entrench the dominance of the current duopoly and negatively affect competition in the market, as the dominant MNOs are likely to outbid competitors in order to obtain spectrum. Even if the dominant MNOs allow MVNOs on their network, they can set high wholesale prices which will result in minimal retail competition and allow the infrastructure based MNO to retain the bulk of industry profits. A WOAN however, can provide open, fair, and non-discriminatory pricing to all retail operators based on single network build. This creates a level playing field for retail operators. Effective competition at a retail level is essential to bring down prices and make wireless broadband affordable.

3 WOAN construct: International experience

3.1 The proposed WOAN construct is WOAN model where operators may choose whether to purchase capacity from the WOAN, subject thereto that all unassigned sub 6GHz spectrum is assigned to the WOAN.

3.2 In terms of this model, certain conditions may still be placed on how much capacity can be purchased, and whether purchases can be geography-specific, in order to encourage retail competition or encourage extension of broadband service into rural areas. This is a free-

[12] Akamai 1Q17 State of the Internet report https://www.akamai.com/fr/fr/multimedia/documents/state-of-the-internet/q1-2017-state-of-the-internet-connectivity-report.pdf
[13] Akamai, Op. Cit.
[14] ICASA op cit, Graph 21
[15] http://www.techreport.co.za/vodacom-lte-now-covers-75-8-south-africansvodacom-lte-now-covers-75-8-south-africans/ 7,900 sites were claimed to be LTE capable.

enterprise model, in that the WOAN must win business based on the basis of providing better capacity more cost effectively than existing MNOs could have done for themselves.

3.3 Mexico is an example of an optional wholesale model. In Mexico, the government was faced with a market situation in which a single operator had close to 70% mobile market share and prices for mobile services were high. By the end of 2015, 36% of the population subscribed to mobile broadband services.[16]

3.4 Similar to the approach set out in SA Connect in South Africa, Mexico embarked on a multi-pronged digitisation strategy with its 2013 National Digital Strategy in order to promote universal and affordable access to broadband services. Mexico's national policy for 'universal digital inclusion' aimed at guaranteeing access to broadband for 70% of households, and 85% of small and medium enterprises. Perceived as a solution towards the quicker achievement of universal and low-cost broadband service, the establishment of a wholesale wireless mobile network (Red Compartida) represents one of the initiatives pursued.[17] The Red Compartida procured an initial funding of US$ 2.3B from various sources including multinationals, equipment vendors, local and foreign banks and investors.

3.5 A major objective of the Red Compartida project is to increase 4G population coverage. The baseline requirement of 85% population coverage became a 92% population coverage commitment by the selected wholesale operator which is to be met by 2024, i.e. seven (7) years from network deployment, starting in 2017. For the ~8% of unserved population, there could further be reliance on a fund similar to the USAF in South Africa[18].

3.6 According to GSMA (January 2018), 3G (4G) services are available for 95% (85%) of the population in Mexico but expanding coverage to 98% of the population would require coverage of 1.2 million km^2. In South Africa, the same report indicates 3G (4G) coverage proportions of 99% (and 75%)[19] of the population (across total land area of 1.2 million km^2). In South Africa,

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[16] GSMA, "Country Overview: Mexico", 2016 Edition
[17] The expansion of the fibre network (Red Troncal) as a wholesale high-capacity transport network, and the use of satellites (MexSat system) for serving remote regions, are also contributors to the 'connectivity' solution.
[18] Based on the latest USAF 2016-1017 report, achievements have fallen short of expectations. The USAF program will be now redirected to a new program, the Digital Development Fund.
[19] ICASA figures for 2016, See Appendix B

the same report indicates proportions of 99% (75%[20]) of the population (across 1.2 M km^2). There is an expectation that coverage should precede capacity enhancement. Deployment milestones and coverage benchmarks for the Red Compartida have been agreed as shown below.[21]

Year	Milestone
2016	Award of the public-private partnership contract in November 2016
2017	Beginning of the deployment of the network
2018	At least 30% of the population covered by March 2018
2020	At least 50% of the population covered by January 2020
2021	At least 75% of the population covered by January 2021
2022	At least 85% of the population covered by January 2022
2023	At least 88.6% of the population covered by January 2023
2023	At least 92.2% of the population covered by January 2024

Source: Information provided by the SCT.

Coverage/date objectives in Mexico

Coverage obligations include designing for a minimum user throughput of 1 Mbps uplink and 4 Mbps on the downlink, when measured at cell edge in an outdoor environment.

3.7 In Mexico, critical to the execution of the strategy, i.e. to lower deployment costs and speeding up deployment, the 700 MHz band, based on the Asia-Pacific plan (or APT), was designated as the wholesale spectrum band. The band was cleared of TV broadcasting upon the completion of the analog to digital TV transition by the end of 2016. The selected wholesaler would benefit from a 20-year spectrum LTE licence at an annual right to use fee of $0.02 /MHz-population.

3.8 It is a greenfield network provider with no legacy technology (i.e. 2G or 3G) to fall back onto. In that context, the wholesaler will need to negotiate interconnection agreements with all providers, including for roaming. To address competitiveness, and ensure leverage of existing assets, the Instituto Federal de Telecomunicaciones, or IFT, declared the dominant fixed and mobile operator a preponderant actor thereby, imposing a specific set of rules, or asymmetric rules. Preponderance is ascribed when a stakeholder's national market share exceeds 50% in

[20] ICASA figures for 2016, See Appendix B
[21] Extracted from OECD, "Policy and Regulation in Telecommunications in Mexico", March 2017

its sector of operation. Those rules, meant to foster competition in the telecommunications market, and speed up deployment in part, cover obligations regarding mandatory sharing of passive infrastructure (e.g. ducts, towers etc.) and rights of way with other parties, local-loop unbundling, and inter-connection rates.[22]

3.9 Incumbent mobile operators are not allowed to participate as investors in the structure of Red Compartida. However, they can become subscribers, with no commitments imposed on them to for example, purchase a minimum amount of capacity. The Red Compartida is also seen as a way of promoting the arrival of new entrants like MVNOs and other resellers towards more competition. Agencies from the government sector will be encouraged to sign up. Absent the allocation of spectrum, use of the WOAN, while not legislated, remains the only option for public safety agencies to have access to mobile broadband services.[23]

3.10 The establishment of the Red Compartida is not tied to future spectrum licences. For instance, in 2016, all incumbent MNOs were allowed to bid for the AWS spectrum.[24] For instance, in 2016, all incumbent MNOs were allowed to bid for the advanced wireless service (AWS) spectrum and, in 2017, the regulator authorised the 'deemed preponderant' operator to provide services over an entire 60 MHz block of spectrum in the 2.5 GHz band, per a business arrangement between the operator and the 2.5 GHz licensee.

3.11 Incumbents in both Mexico and South Africa have access to low-band spectrum, i.e. 850 MHz in Mexico and 900 MHz in South Africa, but there are distinctions, especially if re-farming is an option. In Mexico, all major MNOs have access to a contiguous 2x10 MHz block while only one South African operator currently has access to a contiguous 2x10 MHz block; unless the South

[22] The 1,400-page long regulation can be found at http://www.ift.org.mx/sites/default/files/pitfext270217119verpub_1.pdf (accessed on 01/04/2017)

[23] For years, the regulators on both sides of the US-Mexico border argued on the future band plan for 700 MHz. Of particular note, was the refusal by the Mexican regulator to allocate spectrum for broadband public safety services. Airbus, an equipment supplier for the two major public safety networks in Mexico, has already filed with the IFT to become a 'Secure MVNO" on the Red Compartida network, to serve upwards of 200,000 emergency personnel users. See https://www.rrmediagroup.com/News/NewsDetails/NewsID/15657 (accessed 01/10/2018)

[24] Advance Wireless Services spectrum in the 1700/2100 MHz band for mobile voice and data services used in the USA, Canada and Latin American countries.

African 900 MHz band is re-channelised[25], re-farming to an efficient 2x10 MHz LTE block is not possible.

3.12 Concerning rights of way, licences, permits, etc., the Mexican government will not provide preferential treatment towards the construction of the network. These remain the responsibility of the wholesaler.

Lessons learnt from Mexico

- No incumbent operators should be allowed to participate in the WOAN
- Ensure autonomy of the WOAN and limited government involvement through guarantees and subsidies (eg by means of a universal service fund)
- Minimal or no charge for spectrum licence fees
- Longer concession period for spectrum licence i.e. minimum 20 years

3.13 In Kenya, in 2011 the Government launched an Expression of Interest (EOI) for the creation of a wireless wholesale LTE network leveraging Kenya's digital dividend spectrum band. This was an Optional Wholesale model, but only for LTE. Following this EOI, nine companies, including local operators and manufacturers (Safaricom, Orange, Airtel, Yu/Essar, KDN, MTN, NSN, Alcatel-Lucent, and Epesi.com) agreed with the Kenyan Government treasury to form a consortium (August 2012) working on the set up of a PPP (Public Private Partnership) towards the construction of the new network.

3.14 In Kenya the attempt was to have all the retail service providers participate in the Wholesale network. This led to extended, fruitless negotiations. By the end of 2013, Safaricom, the dominant operator in Kenya with 85% market share (4Q2017), exited the consortium. Reasons listed by the press for the initiative stalling out included the frequency band (2.6 GHz rather than the Digital Dividend 800 MHz band) and the slow progress towards the establishment of

[25] ICASA prescribed a Radio Frequency Spectrum Assignment Plan for the 900 MHz band (IMT900), which proposes to optimise the band so as to provide contiguous spectrum for all three incumbent licensees by 31 March 2020 at the latest(Government Gazette No. 38640, Notice 275 dated 30 March 2015)

the new wholesale operator[26]. Successful establishment of a WOAN would have facilitated the entry of retail competitors so resistance from Safaricom would be expected.

Lessons learnt from Kenya

- Ensure that the WOAN is not associated with any retail operation.
- Establish the WOAN as a public/private partnership entity and avoid government consultation processes
- A clear and stable regulatory framework, political support and mechanisms to swiftly resolve technical, regulatory and legal challenges by electronic communications operators are essential to both attract investors and ensure the achievement of objectives

3.15 In June 2013, the Government of Rwanda and Korea Telecom (KT) entered in a 25-year Public Private Partnership (PPP) to install and activate a national LTE mobile broadband network. KT Rwanda Networks was established to deliver this mobile network with a 95% of the population coverage target within 4 years. Per the regulations, and despite protest by incumbents, no other operator but KT was allowed to invest in 4G networks, ie. it is a Single Wireless Network but only for LTE. The arrangement was for Korea Telecom to inject $140 million (about Rwf91 billion) in infrastructure and expertise, while government was to provide fibre optic network assets, spectrum and a wholesale license. After its inauguration in November 2014, population coverage reached 17% coverage a year later, and 55% after 2 years. According to the operator, the 95% coverage target is on schedule. [27]

3.16 Service uptake is around 20% after 3 years. The Rwanda wholesale network is LTE only, and LTE is the premium, higher performance and higher priced offering. In that context, 3G bundles from incumbents (with low cost 3G user equipment) are more popular despite the lower speed;

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[26] http://rethinkresearch.biz/articles/safaricom-quits-shared-lte-project-in-kenya/
https://www.telegeography.com/products/commsupdate/articles/2013/11/08/safaricom-renews-licence-abandons-open-access-lte-project/

[27] http://www.theeastafrican.co.ke/rwanda/Business/GSMA-calls-for-countries-to-open-up-mobile-network-space/1433224-4082470-format-xhtml-bwvwqt/index.html
http://www.newtimes.co.rw/section/read/201939/
https://www.telegeography.com/products/commsupdate/articles/2018/01/05/rwandan-4g-network-hits-95-coverage/

the only way in which uptake of LTE services can be increased amongst low income individuals is by decreasing prices.

3.17 As the phase-out of 3G networks globally starts in the next few years, this will be less relevant to a South African WOAN, as LTE will become the entry-level standard wireless broadband technology above 2G, with 5G the 'premium G'. Various other explanations have been offered for why the wholesale update is not higher, including:

- Existing MNOs will use their own assets, wherever possible. That means encouraging 3G sales on their own infrastructure first, and avoiding the wholesale (LTE) network.
- The wholesaler blames retail service providers for not bringing down retail prices in line with wholesale prices, and suggests that if retail prices had been regulated more uptake would have occurred
- It has been suggested that the small size of Rwanda makes it less interesting for new retail service providers
- Retailers attribute the low 4G adoption to poor coverage, i.e. 4G service is not as ubiquitous as 3G service.

3.18 Lessons learnt from Rwanda

- Avoid over-specification of technology choices, especially where it eliminates low cost alternatives
- Ensure rapid achievement of coverage objectives through open access infrastructure reuse
- Assure that barriers to entry for new retail operators are low, especially to promote competition outside of urban areas

4 Critical success factors for the WOAN

4.1 Technical Feasibility

From a technical standpoint, a successful WOAN is dependent upon several considerations. Access to spectrum and base stations on an open access basis are critical, as well as the leveraging of existing assets under an open-access regime, and new build facilitated and supported by government to speed up network deployment. Further, it should be considered how to construct a network that can

seamlessly evolve to 5G and support new emerging use case classes such as ultra-reliable low latency (URLLC), and massive Machine Type Communications (mMTC).

4.1.1 Access to Spectrum

4.1.1.1 In order to provide both performance and capacity plan for high uptake and maintain the cost effectiveness of large cells, all unassigned HDS must be assigned to the WOAN. All new low-band spectrum in the 700 MHz (2x30), 800 MHz (2x30) and 2.6 GHz (2x70) bands including the remaining spectrum in the 3.5 GHz band should be assigned to the WOAN operator.[28] However, existing licence grants should continue to be honoured as the potential return of spectrum by licensees is a strong disincentive for future investment by private institutions.

4.1.1.2 The WOAN should establish a nationwide coverage by means of low band spectrum capable of good reach / wide coverage in rural areas. Thus, as a fundamental requirement, the WOAN must have access to a significant quantity of low band (below 1GHz) spectrum in order to achieve coverage objectives, as coverage into currently unserved or underserved areas is most cost effectively accomplished by sub-1GHz bands. However, the 2.6 and 3.5 GHz bands are key in ensuring that the WOAN has enough capacity to alleviate any form of congestion especially in urban and highly dense areas for high demand for data. For example, in Mexico, a licence for 90 MHz (2X45 MHz) in the 700 MHz band (band 28) based on APT plan was issued on an exclusive nationwide basis to the wholesaler, Red Compartida, after the band was cleared of TV broadcasting In Kenya, the 2.6GHz band was granted to the wholesaler as an interim measure until the low band could be cleared of TV broadcasting. In this regard, in South Africa clearance of the spectrum (700 MHz and 800 MHz) occupied by TV broadcasting service must be accelerated.

4.1.3.3 Moreover, the more spectrum made available, the greater the number of subscribers who can be served from a cell with a reasonable broadband data rate. This means a fewer number of cells required, which significantly improves the cost effectiveness of the network deployment. Thus assigning all unassigned spectrum in the 700, 800, 2600, and 3500 MHz bands to the

[28] From a device eco-system standpoint, the combination B28 (700) + B20 (800) is not common, but the assumption is that the WOAN will deploy both B20 and B28 on the same site therefore, it is possible that some WOAN devices will support B20 (plus all other bands except B28) while others will support B28 (plus all other bands except for B20). This will ensure a much larger eco-system of devices to select from.

WOAN will contribute to making the use of the WOAN attractive to existing players who need additional capacity. This contributes to enough capacity being made available for smaller players and new entrants to compete effectively, encouraging service based competition, with the potential to reduce costs substantially.

4.1.3.4 Depending on the future amount of spectrum allocated to mobile services and identified for IMT becoming available in South Africa, be it contiguous or not (in the eventuality of multiple bands assigned to the WOAN licensee), the roll-out of so-called carrier aggregation represents an approach to achieving those broadband service level targets set by SA Connect e.g. an average user rate of 100 Mbps by 2030.[29]

4.1.2 Minimally prescriptive wrt technology

4.1.2.1 In principle, the setup of the WOAN should be as minimally prescriptive with respect to technology as possible. This ensures that the structure does not distort economically efficient choices of technology, and that the model is robust in that the most economically efficient choices are made over time as technology costs and capability change.

4.1.2.2 For example, the most desirable current technology would be LTE, but by 2019 this will start to shift to 5G. The 5G technology will enable a higher spectral efficiency, hence an 'easier' way of achieving, with less spectrum, the kind of data rate objectives highlighted in SA Connect. However, the early introduction of such a technology may not favour the low-cost approach pursued by the government.[30] Therefore**,** it is desirable that the deployed infrastructure be LTE/5G flexible. Since end-users and devices are managed by service providers, rather than the WOAN licensee, upgrades and other new features introduced in the access network should account for device capabilities and, potentially, the ability for subscribers to afford new devices, in order to benefit from such improvements.

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[29] As an average (mobile) wireless metric, the figure may be achievable with multiple antennas, higher level modulation levels, larger bandwidths or a combination thereof, but the impact on deployment cost should not be ignored. A distinction between achievable targets under mobile and fixed environments is probably warranted as part of a review of SA Connect objectives

[30] As part of its Release 15 specifications, the 3GPP Standard body has identified a number of potential bands ranging from 700 MHz to 40 GHz

4.1.2.3 A minimally prescriptive approach further ensures that the scope of the WOAN is not artificially constrained to economically non-optimal technology choices; for example, that the WOAN is not prohibited from distributed edge cloud hosting that enables more cost effective and lower latency connectivity and content delivery. The WOAN might also make use of satellite technologies in very remote areas. The structuring of the WOAN must thus be carefully done to not embed deterministic assumptions about the technology to be used as this has in the past proven to be problematic.

4.1.3 Deployment

4.1.3.1 The WOAN should be rolled out to achieve nationwide LTE/5G coverage comparable to the ~99% population coverage of today's 3G networks, more than doubling available network capacity, and approximately tripling user experienced throughput possible if a retailer subscribes to sufficient WOAN capacity. The WOAN will need policy and regulatory support to ensure that incumbent operators are mandated to share their passive and active infrastructure including making available the 11,000 existing radio sites.

4.1.3.2 The WOAN should establish coverage in both new areas (e.g. rural and under-serviced areas) and existing urban areas. Without the urban population coverage, new retail operators would be dependent on roaming agreements with their competitors to obtain urban coverage, which would compromise the ability of those retail operators to offer service cost effectively. Furthermore, urban areas are also areas where the WOAN operator (like an incumbent MNO) can make up for less profitable rural areas.

4.1.3.3 Ideally, a great deal of the population coverage objective with broadband capacity and performance should be achievable in the low band spectrum from an estimated 11,000 existing radio sites. Because of the additional capacity provided by HDS, some sites may require improved transport capacity to support the higher available bandwidth and data rates[31.] The footprint of current 3G services offered by major MNOs on the 900 MHz band covers close to 99% of the population, hence a large fraction of the rural population.

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[31] "We extended our high-speed transmission to 92.1% of our sites," said Vodacom" See http://www.techreport.co.za/vodacom-lte-now-covers-75-8-south-africansvodacom-lte-now-covers-75-8-south-africans/

4.1.3.4 Aiming at a better broadband experience (in particular, higher uplink data rates) at cell edge requires the buildout of more sites. For instance, increasing the target minimum rate at cell edge has a significant impact on costs; going from 384 kbps to 1 Mbps cell edge uplink performance can lead to a ~60% increase in the rural cell count.

4.1.3.5 Further, deploying an LTE network at lower spectrum bands of 700/800MHz will benefit from the slightly better propagation characteristics than existing 900 MHz deployments but, when combined with other system parameters, result in a comparable footprint with a slightly better uplink cell edge rate; the major difference though, lies in a better average downlink performance and hence greater effective capacity. A 1:1 overlay replacement of HSPA+ with LTE is common in the industry.

4.1.3.6 Since urban areas are typically built for capacity, i.e. not coverage limited (except for indoor service objectives), targeting a higher cell edge rate would ultimately drive higher the count of rural sites.[32.] This is a common outcome when planning for mobile coverage of countries with a large rural to urban area size ratio, and a very low rural population density. As SA Connect rightly noted with regard to rural and remote areas: 'Satellite is generally not cost effective, but is a viable solution to reach the most rural and remote areas'[33.] By the same token, a lower or higher desired average throughput will lead to a reduction or increase in site count.

4.1.3.7 The ('minimum average') coverage and service level targets developed by SA Connect do not make a distinction between fixed and wireless services. However, when applied to a mobile wireless service, meeting those targets can be challenging, especially for rural areas. Creating larger cells with the purpose of lowering the required number of sites, and therefore site deployment costs, without augmenting the cell capacity, may not achieve the desired service speed objectives. For example, in the case of the Mexico's Red Compartida network, the government set an 85% population coverage target after 5 years, with a specified cell edge throughput per user of 1 Mbps upstream and 4 Mbps downstream; they could have achieved a broader coverage for the same investment with a more modest cell edge performance target.

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[32] A higher cell edge rate will improve both uplink and downlink throughput per user, at the expense of a larger site count.
[33] Department of Communications "South Africa Connect: Creating Opportunities, Ensuring Inclusion", South African Broadband's Policy, 20 November 2013

4.1.3.8 In urban areas, the limiting factor that requires a greater number of cell sites to be built is generally not cell reach but capacity. The number of users times the average user throughput will fill the cell's capacity; if the operator cannot turn on new carriers, then they must split the cell (establish new cell sites) or take other actions to load from the cell. The larger the amount of spectrum available per cell, i.e. the larger the capacity of the cell, the larger the number of users which can be served. For example, for the same amount of spectrum available, designing a network to cover a certain population with an average downlink usage per user of 5 Mbps will require 5 times the number of cells required for a 1 Mbps average usage. The same relationship will roughly apply when designing for a data consumption per subscriber of 5 GB/month vs. 1 GB/month.

4.1.3.9 In addition to adding capacity for urban sites, the WOAN can enable higher performance in the sense of user experience. If for example, a retailer is purchasing from the WOAN two non-contiguous 10 MHz component carriers from 700 MHz plus one 10 MHz carrier from 800MHz, for a total of 30 MHz all combined via carrier aggregation; this would allow 3x the performance of today's LTE networks with 10MHz.[34]

The WOAN should be deployed in 3 phases.

Phase 1 Nationwide coverage from existing sites

4.1.3.10 The initial phase of deployment should seek to establish as much coverage as possible without new site deployments, by leveraging the existing fixed radio infrastructure, through the addition of new radios / antennas, and baseband equipment, and backhaul facilities. Although planning should aim at leveraging all existing sites the reality is that issues of tower loading, estate space etc. may not result in an optimal design in the early deployment stages, even

[34] It is likely that not all devices will support carrier aggregation; also carrier aggregation combinations of Band 20 and Band 28 carriers have not been considered by 3GPP (by December 2017)

under an open-access regime.[35] Therefore, as a preliminary estimate[36] and contingent on antenna and tower/site availability, it can be assumed that the construction of a WOAN operating at 700 MHz and 800 MHz could leverage existing 3G 900 MHz site locations to match the current 3G coverage footprint, but with significantly better performance. Existing tower loading can be mitigated by mandating open access that will encourage operators to share passive and active mobile infrastructure. See Appendix A for further details.

4.1.3.11 Antenna sharing is an option but the current 900 MHz antenna performance (gain, pattern) may not be optimal at 700 MHz and 800 MHz, and/or the addition of splitters and combiners will impact existing coverage. It will be relatively easy (at a cost) for current 900 MHz licensees to swap 900 MHz antennas, e.g. in the rural areas, with single multi-band antennas covering both low-band and high-band spectrum and re-optimise the network.[37] In urban areas, not all current radio sites will necessarily be used initially, as launch capacity requirements will be modest, and coverage at 700/800 MHz is equal or better (except for indoor) than coverage established for higher bands.

4.1.3.12 Although the construction and deployment of the network is the responsibility of the WOAN provider, support from government warrant intervention with regard administrative processes for permits, licenses and the likes. The consideration of leveraging incumbents' passive assets, public assets and other rights of way is imperative for the ubiquitous provision of broadband services.

4.13.13 As it relates to affordability, volume (capped or uncapped) may be important for fixed and mobile services charging but broadband speed is what actually defines mobile broadband. Since the 2013 SA Connect paper defines average speeds and population coverage, there are three inter-related radio design aspects to the WOAN technical construct: (universal) coverage, (wholesale hence retail) volume pricing, and transfer speeds, all of which impact the business

[35] This implies that the WOAN provider would need access to an inventory of existing assets, with details of physical space and antenna clearance for each site location

[36] Base stations for both technologies have a multitude of parameters which engineers can tweak during deployment optimization.

[37] One example of multi-band antennas is shown here http://products.rfsworld.com//rfs-announces-ultra-broadband-lte-multi-band-antenna-additions-to-its-rf-x-tremetm-base-station-port,62,1,pressreleases,790.html (accessed 17 January 2018)

model of the WOAN operator. From a typical mobile operator investment perspective, the cost of deploying the radio access portion of a large network, including associated services, represents a major share of the overall spend. However, typical RAN deployment costs are made up of site costs/civil works, powering, backhaul, towers, etc. as opposed to the antenna, radio, and baseband equipment, which is largely the only additional cost when the WOAN adds new carriers to an existing site.[38] A 'low-cost' network buildout and operations should imply low wholesale rates, and low retail pricing, but may not necessarily achieve SA Connect speeds.

4.1.3.14 With the full 700 MHz and 800 MHz spectrum blocks assigned to the WOAN, or 2x60 MHz per cell, and an average downlink spectral efficiency of 1.6 bits/sec/Hz (with neighbour cells fully loaded), each sector of a site should support 96 Mbit/s of downlink throughput, or about 288 Mbit/sec of available (downlink) bandwidth for a 3-sector cell site.[39] For rural areas, because of the larger inter-site distance the average downlink efficiency drops to about 55 Mbit/s, but a possible deployment of 4-branch base station antennas will bring it back up to about 60 Mbit/s. The achievable average throughput per user will be a function of the number of users falling within the footprint, and the neighbour load.[40] The performance objective to be defined has a significant impact on cost and coverage as well as the quality of experience. As of 2016, around 99% of population are said to have access to 3G coverage and 75% to LTE coverage[41,] but this says nothing about the actual service experience, which is a function of cell size, spectral width, user load and other factors. Therefore, a pragmatic approach is proposed: in phase 1, achieve the best possible outcomes that can be accomplished with minimal cost, then proceed to coverage gap filling for phase 2 and 3. At the completion of this Phase 1, it should be possible to fill in coverage gaps and ensure coverage quality and determine the cost and benefits of further phases.

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[38] Although as noted elsewhere there will sometimes be incremental costs incurred for tower strengthening, increasing battery capacity, etc.

[39] The assumption here is that the spectral bands are used as individual 10 MHz wide channels. For rural regions, because of the large inter-site distances expected, spectral efficiencies are lower but we assume herein that neighbor cells are not fully loaded. Whereas MIMO per se may not be too useful in rural regions, because of reduced multipath, the use of transmit diversity will be of use.

[40] To illustrate: A single cell configured with 60 MHz could serve more than a thousand subscribers at an average downlink rate of 2 Mbps, assuming a 20:1 overbooking factor, a 60% load and with all neighbor cells loaded,

[41] Appendix - ICASA 2nd report on the state of the ICT Sector in South Africa, 31 March 2017, Graph 21

Phase 2 Coverage gap filling

4.1.3.15 Phase 1 is expected to be economically viable on a standalone basis: more profitable urban cells will make up for less profitable or unprofitable rural cells. It is also expected to provide excellent nationwide population coverage as good as current 3G coverage (~98% population) but with much improved throughput and capacity.

4.1.3.16 The objective of the second phase should be to fill in coverage gaps. Phase 2 may require new site construction in rural/remote areas which, in combination with wholesale prices set to provide affordability, would not normally be profitable to build. However, Government will be in a position with a solid Phase 2 plan to determine how much better coverage they wish to fund by means of for example, a contribution from the USAF, should the desired coverage be greater than that occurring through WOAN excess profit re-investment. The cost of expanding coverage to rural and remote areas costs would likely be high because most of these sites would be in more remote areas, requiring expensive new backhaul, powering, probably containers / shelters, and even roads.

4.1.3.17 Affordability and coverage are to some extent conflicting objectives. For example, to achieve 100% geographical coverage would be very expensive and these higher network costs would have to be reflected in higher wholesale costs, which would limit the ability of the WOAN to bring down retail prices and make wireless broadband affordable. Therefore, the approach should be the subsidisation of coverage in areas that would not otherwise have been economically attractive for Phase 2 deployment.[42]

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[42] For example, in New Zealand, an industry levy (Telecommunications Development Levy) has been used to fund the Rural Broadband Initiative for service to rural and remote areas: Because is it not cost-effective to provide Ultra-Fast Broadband (UFB) in every rural community, the Rural Broadband Initiative (RBI) is providing faster internet to hundreds of thousands of rural homes and businesses outside UFB areas. *New Zealand's telecommunications* networks are generally owned and operated by private network operators. In rural and remote areas where the networks have not previously invested in coverage, grant funding from an industry levy has been used – the Telecommunications Development Levy. This recognised that intervention was required to ensure rural and remote areas of New Zealand have access to fast broadband and mobile services. Over $430 million in grant funding from the Telecommunications Development Levy has been allocated to RBI, to ensure that more New Zealanders can experience the benefits of improved connectivity http://www.mbie.govt.nz/info-services/sectors-

4.1.3.18 One may be able to fill coverage gaps, i.e. reduce the costs of rural deployment, by extending the cell range while maintaining throughput; for example, opting for a slightly costlier 4-branch transmit and 4-branch receive configurations could reduce the cell count by nearly 35%. Although such configuration is available from equipment vendors for the low-band spectrum, it has not gained traction yet. Another option is to deploy fixed broadband wireless networks with 4 or 6-sector configurations, to at least introduce broadband at home via fixed high-gain modems. Reducing the cell count can also be achieved by aiming at a lower quality of service, i.e. by designing for lower edge rates for a reduced average broadband rate, thereby enabling large cells. Alternatively, satellite technology represents an option for remote area coverage, possibly a subsidisation of service costs (plan plus satellite modems).

4.1.3.19 There are several different ways that enhanced coverage beyond Phase 1 might be funded, but the simplest is for Government to simply decide which expansion projects it is willing to fund and do so. An alternative or complementary approach would be to cap the maximum return on capital, and require the WOAN to keep under that cap, by investing any excess profits, with coverage expansion a key investment priority.

Phase 3 Capacity augmentation

4.1.3.20 At some point, the initially installed capacity will be insufficient (largely in urban areas, See Appendix D: Impact of the WOAN on Urban Demand) and the WOAN operator will need to explore means to augment capacity, which may include new carriers, cell site splitting, new radios in new spectral bands, or microcell offload. This would be geographically targeted investment and may overlap in time with Phase 2. Please see Appendix B for more details.

4.1.4 Service Delivery Models

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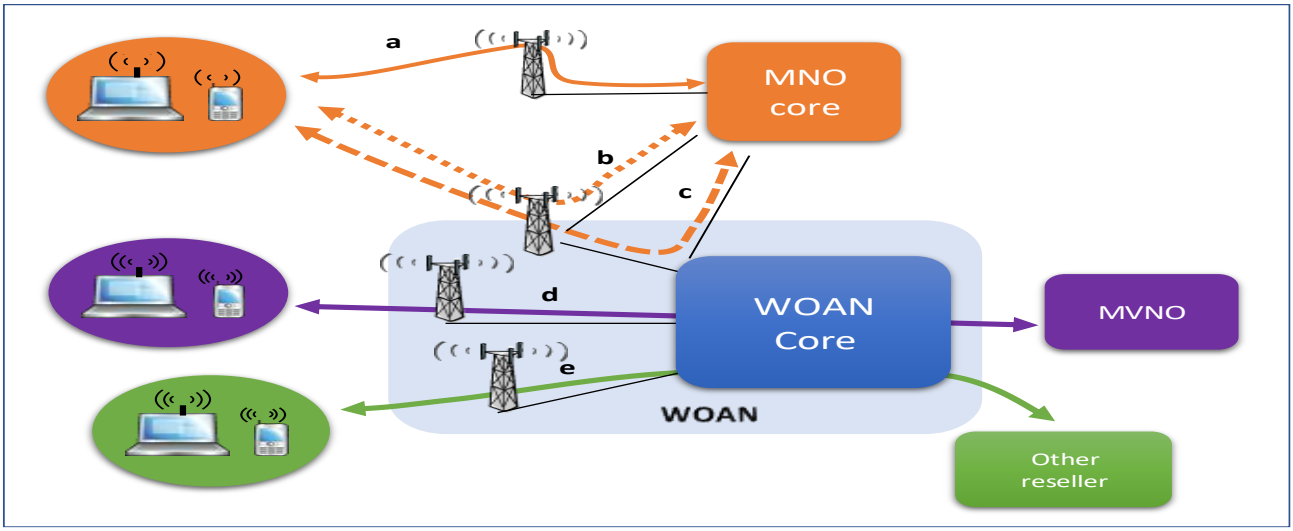
industries/technology-communications/fast-broadband/broadband-and-mobile-programmes The USAF, which is a similar program in terms of objectives, is being reviewed.

4.1.4.1 The WOAN should sell to and support through appropriate wholesale offerings, the requirements of various operators. There are multiple models for how retail and wholesale providers can interact. The WOAN may also optionally provide interconnection and roaming arrangements.[43] The WOAN's success is best optimised by supporting all of these models for the highest possible utilisation of WOAN assets. All models will have interfaces and data exchange with the WOAN's Operations Support Systems. The models are:

- RAN Sharing (MOCN style shared RAN only)[44]
- MOCN (MOCN style shared RAN + Regional/National Transport)
- MVNE (Shared RAN+ Transport + shared Core + Interconnect/roaming)

In all the above mentioned instances, network operators share the wholesalers' spectrum, antenna, radio, and baseband.



RAN sharing (MOCN style shared RAN only)

[43] Under this framework, inter-connection and roaming are essential but could either be provided by the WOAN or negotiated directly by the MVNO

[44] 'RAN sharing' is also referring to a MOCN architecture but we use the term 'RAN sharing' simply to denote utilization by a wholesale MNO customer of the (mobile) radio portion of the network only, e.g. cell site and equipment excluding transport facilities; hence the emphasis on 'transport' for the 'MOCN' option

4.1.4.2 As illustrated in **Error! Reference source not found.**, the first category **'Shared RAN'** is illustrated by path b whereby an incumbent MNO purchases from the WOAN a share of the WOAN available capacity. The WOAN does not provide transport and the MNO uses its own transport (Path 'b'). A standards-based capacity/RAN sharing arrangement, which is enabled through capacity slicing model, allows for multiple independent operators to control radio resources as though it were their own RAN.[45] WOAN capacity, which can be made available on the basis of a static, or dynamic allocation of radio resources, allows the MNO to manage its traffic (e.g. bearers, number of connections, QoS, etc.). Since MNOs are both infrastructure and service providers, the MNO may not require transport provided by the WOAN (e.g. via VLAN provisioning).

MOCN (MOCN style shared RAN + Regional/National Transport)

4.1.4.3 The second case **'**MOCN' adds transport to the operator's own core from the shared RAN, per path 'c' in figure 2. The MNO subscriber, with the appropriate multi-band device (support for MNO spectrum band and WOAN spectrum bands) would benefit from coverage offered through the MNO service footprint ('a') and the WOAN footprint (b and/or c).[46]

MVNE (Shared RAN+ Transport + shared Core + Interconnect/roaming)

4.1.4.4 Whereas a mobile network operator is able to leverage its existing network core and perhaps transport facilities, the typical mobile virtual network operator (MVNO) will rely entirely on the WOAN infrastructure, including RAN, transport, and Core resources, for end-to-end services. This is the third type of service **'**MVNE' (Mobile Virtual Network Enabler). As a MVNE, and as a new greenfield infrastructure provider, the WOAN is also expected to ensure roaming

[45] In the case of the Mexico's Red Compartida network, the government envisions existing mobile network operators, enterprises, and new entrants to become wholesale customers. Further, the government is not prescriptive on the minimum amount of capacity that should be purchased by incumbent MNOs.

[46] In areas where footprints overlap, there will be opportunity for aggregating the combined resources for a higher service level. On the other hand, the commercial arrangement may be limited to underserviced areas only.
Since the WOAN spectrum belongs to the WOAN provider, it becomes the responsibility of the MNOs to ensure those multi-band devices are available.

capability onto other MNOs networks. The MVNO will typically purchase a volume of minutes and Gbytes on a regional basis. There is no reservation of air interface capacity for any given MVNO and the MVNO will have little or no capital investment aside from OSS/BSS systems needed for retail service delivery such as billing systems.

4.1.4.5 A full description of how a WOAN could be technically structured is provided in **Appendix A .**

Multiple service support and Quality of Service

4.1.4.6 As a key communications infrastructure provider, the WOAN should have demanding targets in respect of network for reliability and availability, and therefore on security, resiliency, and service restoration capability. These should be competitive and comparable to other providers utilizing the same technology in equivalent circumstances. The reliance by multiple service providers, particularly new entrants, on a single network infrastructure provider calls for a network designed and engineered for reliability and robustness. High reliability will imply a variety of measures such as the design and engineering for core and transport redundancy (geo, path and equipment level), addition of backup power systems, and fast and skilled response teams. In this regard, the usage of the network by emergency and other security agencies may require a high degree of reliability, e.g. in terms of stringent service availability and other performance indicators. The same will apply to any use of mobile networks for industrial control, tele-operations (remote human operator control of vehicles, mobile robots, and drones), security systems, and other use cases.

4.1.4.7 The WOAN might initially support five application classes (voice and SMS/MMS, browsing, streaming video, file transfer, public protection and disaster recovery) and two configurations (mobile endpoint and fixed endpoint). A fixed endpoint may support many end users, e.g. a village with a fixed wireless LTE end-point with WiFi relay to end user devices, however fixed wireless access can also support much improved reach and performance. The WOAN should be designed to efficiently support a variety of end application quality requirements and allow wholesale offerings that are differentiated by assured throughput, latency, massive IOT device support or other technical criteria as long as such offerings are freely and impartially accessible to all retail operators.

4.1.4.8 There are special attributes of Quality of Service (QoS) which apply to some public sector agencies such as emergency or security personnel communications. In particular, the availability of special classes of services or of priority mechanisms, including pre-emption, are common requirements. Implementing these features add to the cost of the radio network, so upfront commitment by the Government should occur that the WOAN will be used for this purpose.

5 Commercial feasibility

5.1 Incentives for the WOAN

5.1.1 Since it is relying on private capital funding, the WOAN must be economically attractive. There is a number of incentives which support economic success, and therefore the ability of the WOAN to attract private investors. They include:

- Initially, rights to unassigned sub 6GHz spectrum. Specifically:
  - 2×30 MHz in the 700 MHz band (703 MHz-733 MHz/758 MHz-788 MHz) and
  - 2×30 MHz in the 800 MHz band (791 MHz-821 MHz /832 MHz-862 MHz) and
  - 180GHz (TDD) in 3.5GHz and
  - Future 3.3-3.4GHz spectrum
  - Future L-Band spectrum (1427-1518 MHz)
  - with a 20-year concession period[47]
- Regulatory mandated open access assets, roaming agreements, etc.
- Interconnection, traffic termination etc. at regulatory prescribed prices based on current figures and cost based benchmarking
- Controls on competitor behavior

[47] The 2.6 GHz is contemplated for capacity relief and may be assigned as a regional license. The status of the 2x5 MHz block in the frequency band 825-830MHz/870-875 MHz (licensed to Neotel) is yet to be determined

5.1.2 Further, a published study about the potential for a wholesale delivery model in a country with a sizeable rural environment, and areas of low average population density[48] indicates that a WOAN model is viable when:

- it has a positive economic basis that successfully attracted private investors
- it is technically feasible to implement (asset sharing)
- it appears to be encouraging the right market outcomes in terms of increased competition leading to greater affordability and service uptake and expansion of geographic coverage into rural areas.
- the estimated affordability of services results in a higher wireless broadband service adoption, with a subsequently higher economy activity; and
- taxes generated by an increased GDP would exceed the revenues the government can expect from traditional auctions.

5.2 Fast Start

A slow rollout, delayed by negotiations, legal challenges, delays in clearing digital dividend spectrum, or other factors will adversely affect the viability of the WOAN for multiple reasons. Delayed availability will allow WOAN opponents to claim that it is not a viable approach, and lobby for a public spectrum auction or other alternatives. Moreover, delays in WOAN capacity becoming available will force MNOs to find and exploit other technical alternatives to the WOAN to meet demand.

5.3 Public-Private Partnership

A purely public basis for the WOAN would be problematic for several reasons most notably difficulty in Government funding such a development and inadequate expertise building and managing a network by Government.

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[48] Alcatel-Lucent, "Open Access LTE", 2014 http://www.tmcnet.com/tmc/whitepapers/documents/whitepapers/2014/9903-open-access-lte.pdf (accessed 15 January 2018)

The Red Compartida in Mexico was implemented as a Public Private Partnership, but the contribution of the government is primarily spectrum and it is not part of the shareholder base, nor is it involved in network design, deployment or commercialisation. The spectrum license is further almost free since the government collects a yearly spectrum fee at a very low fee per MHz-pop.

5.4 Regional structure

5.4.1 The WOAN may be best organised to support wholesale services that are regionally based and allow investment by regionally based entities which may have an interest in improving coverage in their region. There are multiple reasons why a regional structuring of the WOAN are desirable.

- A regional structure (not necessarily administrative districts such as provinces, but population clusters with a shared interest in local economic development) allows investment by residents and other beneficiaries in their region, allowing for economic participation in a venture that is directly linked to their communities. For example, see http://swiftnetwork.ca/ for a regionally based initiative to provided broadband services into currently underserved areas in South-Western Ontario Canada that is supported by the communities of the regions that will benefit from that network.
- A regionally based segment of a WOAN may be able to best understand the unique needs and geography of that region, and may be able to develop relationships with regional government that facilitates rollout, e.g. rights of way, site/planning permissions.
- A regional structure allows for retail service providers to serve only one region, as opposed to being required to be a nationwide provider. This is particularly relevant to the provision by the WOAN of fixed wireless broadband (where service delivery may be very targeted) and communication services that are highly localised within a community of interest and where a decentralised model therefore supports low cost localised traffic routing.

5.4.2 What is proposed is unlike the former Under-Served Area Licenses (USALs). In that scheme, local entrepreneurs who lacked both the skills and the capital were expected to build, operate, maintain, and be the sole seller of retail services within local areas. In the regional structure we are suggesting, all spectrum licences and skilled staff are within the WOAN. The WOAN

builds, operates, and maintains the network. The WOAN does not offer retail services but enables multiple retail service providers. .

5.4.3 Regional groups or individuals (as well as Provincial and National Government) may contribute to investment in extending the coverage of the WOAN network beyond that established in Phase 1, knowing that they will benefit directly from the build-out in their area. Multiple schemes for local sponsorship or investment in coverage extension are possible.

5.4.4 A regional structure has technical implications, in particular that there must be defined points of interconnection that are at least as decentralised as the smallest region to be served; a highly centralised interconnection model inherently implies a nationwide service. Excessively centralised Points of Interconnect (POIs) were a key bone of contention in Australia's NBN rollout where regional service providers argued they were being discriminated against. With a few number of points of interconnect, it is easier for retail operators to establish wide area coverage, but there are costs being included in the WOAN cost structure associated with such trunking. This could prevent the emergence of regionally based retail service providers, e.g. for fixed wireless services.

5.4.5 The ideal WOAN construct should have both regional and national POIs. For mobile services, wide area coverage is needed (since the user is by definition mobile), either by wide coverage by a single provider, or by roaming agreements. If interconnect points are dispersed then individual retail operators must arrange for transport between the points of interconnect to provide nationwide or wide area service. This is a disincentive for smaller/new entrant/low asset retail operators, as there will be significant semi-fixed costs associated with leasing capacity between the points of interconnect.

5.5 Sufficient Capital and investors

The WOAN must have access to sufficient capital with due diligence verification of the capacity of the proposed investors to fund the required deployment. If a WOAN is to be operated and/or partially owned by one or more split-off division of an existing network operator (which has virtues in terms of skill set and open access arrangements) then that operator must have a complete wholesale vs. retail separation, such that retail operators can be assured that the WOAN is not giving any advantage to any particular retail operator.

5.6 Concession period

A concession period within which the WOAN model will not be substantially changed (e.g. spectrum rights) should be established of a period of 20 years

5.7 Access to spectrum

As discussed earlier, if the only way that a MNO can get access to new spectrum is via the WOAN, this will provide a compelling argument for purchasing capacity from the WOAN in areas where additional capacity is required[49]. The economic viability of the WOAN depends critically on being able to sell in urban areas where both demand and wealth are high; therefore, the WOAN needs to present a competitive offer, in particular for urban capacity needs. For this reason, it is desirable to also include the 2.6 GHz spectrum in the spectrum assigned to the WOAN, since this spectrum (which is more suitable for smaller urban cells) is ideal for urban capacity.

5.8 Wholesale only

The WOAN should not be allowed to operate as a retail service provider. As noted in the case of an attempted WOAN in Russia, allowing a retail operator to manage the WOAN places all other retail

[49] The operator Vodacom has claimed they need at least 2*10MHz in Digital Dividend band and 2*10MHz at higher spectrum https://techcentral.co.za/the-spectrum-crisis-facing-sa-operators/64153/; Also, as TeleGeography states the lack of LTE spectrum has forced Vodacom to look for solutions elsewhere: "*Vodacom has launched a commercial LTE-Unlicensed (LTE-U) service using spectrum in the 5.8 GHz band in a section of Sandton City, located in Johannesburg, TechCentral writes. Despite the commercial launch of the technology, compatible handsets and routers are only expected to be available later this year. The cellco also trialled LTE-U on a controlled environment in Midrand, showcasing download speeds of 217 Mbps by aggregating 10 MHz of licensed spectrum in the 1800 MHz band and two 20 MHz blocks of 5.8 GHz frequencies. Going forward, the company is planning to step up its rollout once LTE-U-suitable smartphones and routers become available* " in https://www.telegeography.com/products/commsupdate/articles/2016/05/17/vodacom-claims-commercial-lte-u-launch/

players in the position of purchasing critical infrastructure service from their direct competitor, which they will avoid.

5.9 Open Access to critical MNO/Tower Company infrastructure

In order to assure a low-cost deployment that supports enhanced affordability and rapid achievement of nationwide coverage, the WOAN needs ‘open access’ to existing (passive) radio site infrastructure and active and passive transport (routers, fibre, microwave) assets of wireless service providers at near incremental cost. An effective open access infrastructure will be critical to the success of the WOAN. Such open access rights include the sharing of high sites, towers and masts, antenna (where possible), optical conduit from top of tower/mast to baseband unit, power feeding and conditioning networks and equipment, power backup including batteries and generator sets, environmentally controlled huts, cabinets, or other enclosures, equipment racks within such enclosures, heating/air conditioning equipment for such enclosures, routing, switching, muxing, optical aggregation and transport equipment, as well as fibre, microwave, PON, or other transport infrastructure providing links to cell sites.

5.10 Pricing

5.10.1 Looking at the WOAN from the perspective of infrastructure owning MNOs such as Vodacom and MTN, they will always prefer to use their own assets unless there are compelling reasons why the WOAN is a better option. The construct of the WOAN must therefore ensure that such compelling reasons exist. The WOAN should give them access to much needed additional capacity and nationwide coverage at a lower cost than they could have achieve had they been granted the spectrum rights themselves. This lower cost arises from the spectrum they do not need to purchase at auction combined with the cost efficiencies of cost sharing across multiple operators. What they lose from the presence of the WOAN is the ability to prevent other retail operators from accessing that same cost effective, high performance, nationwide infrastructure.

5.10.2 The WOAN operator should be able to, at its discretion, set prices which are differentiated by geography, by performance, or by quality criteria or that may vary over time to ensure that wholesale rates remain attractive and competitive for all of the target market segments. However, WOAN pricing may be uniform across areas that are in fact different cost to serve, in order to support achievement of affordability objectives. For example, a single uniform price might be below the rural costs, but above the urban costs. All pricing should be open and available on equal terms to any retail service provider.

5.11 Expandability

The WOAN must not be prohibited from purchasing (or being granted) additional spectrum rights to cope with growth, nor from conversion of site to more sectors, nor from cell-site splits, nor from micro-cellular deployments in loaded hotspots.

5.12 Governance

5.12.1 The WOAN should be operationally autonomous from Government.

5.12.2 Independent of the WOAN itself, there should be a small regulatory oversight group, perhaps ICASA, which should provide the following functions:

- Measuring WOAN coverage, performance, availability, and time to repair
- Tracking the progress of the WOAN against commitments and achievement of objectives
- Providing independent binding arbitration of conflicts between the WOAN and retail service providers, between the WOAN and other providers of wireless networks, and between the WOAN and suppliers of transport, sites, or other infrastructure.
- Setting and revising the performance objectives and requirements placed on the WOAN

5.12.3 Legislation may be required to vest sufficient regulatory and enforcement powers in the Oversight Group.

5.13 Customers and capacity

5.13.1 Government users such as Public Protection and Disaster Recovery should ideally be 'anchor' customers of the WOAN. Legislation must further ensure that a non-WOAN (infrastructure owning MNO) operator who buys capacity from the WOAN does not price lower (eg. to an MVNO) in WOAN covered areas than they price in comparable areas not covered by the WOAN.

5.13.2 The WOAN at its discretion may require retail service providers to contract capacity from some region or minimum breadth of geographic coverage. This is necessary to ensure that an incumbent mobile operator cannot block new entrants by buying out all the cell capacity in selective cells so as to prevent other service providers from achieving contiguous geographical coverage.

5.13.3 With regard to the requirement that a licensee procures 'a minimum of 30% capacity or such higher capacity as determined by the Authority, in the Wireless Open Access Network for a period determined by the Authority', this proposal is problematic for several reasons, including.

5.13.4 Firstly, it may not be necessary; if all the low band spectrum is given to the WOAN, incumbent service providers will find it expensive to meet ongoing capacity growth needs in urban areas without using the WOAN. Secondly, it is not clear how the conclusion was reached that 30% uptake by retailers would be sufficient to make the WOAN profitable. Thirdly, a mandatory subscription condition could undermine the perceived need by the WOAN to assure a competitive cost structure and pricing; it does not have to attract customers because its customers are forced to buy capacity.[50] That might ultimately make the WOAN unable to achieve more than the mandated purchase quota because operators find it more cost effective to find other means to achieve capacity growth.

5.14 Revenue and return on capital

[50] As noted in the national ICT Policy paper, the following principle should be applied:
"The policy maker and regulator must consider the least intrusive mechanism to achieve the defined public interest goal/s, and will consider, where appropriate, alternative models such as co-regulation and/or self-regulation."

5.14.1 It needs to be ensured that the WOAN does not extract monopoly profits. Cost based pricing is a poor way to do this, because it provides no control over costs, and no incentive to minimise same. This could threaten the entire viability of the WOAN. An alternative mechanism would be to cap revenue. This provides an incentive to minimise costs. A wholesale network provider is similar in many respects to a gas or electric utility. A fairly simple model for ensuring an adequate but not excessive return on investment is Building Block Model (BBM) pricing in which a revenue cap is set for the WOAN and/or price caps are set for its services.[51] This cap is set to cover costs if efficiently operated plus ROI. The revenue cap is based on valuing the network and can include pre-approval of future investment. Independent regulatory oversight can ensure the cap is appropriately set. This will ensure an attractive return to investors, but also ensure that the WOAN is not tempted or allowed to extract monopolistic rents and thus compromise the affordability objective.

5.13.2 Another possible mechanism is to define a maximum return on capital that the WOAN may earn. This is perhaps the best approach because once the WOAN has become profitable, any excess profits that would have put it over the cap can be directed into investment to expand coverage, reduced wholesale costs, and/or enhance capacity and performance. This could be the funding mechanism for Phase 2 coverage expansion. The Cap should be set sufficiently high to attract private investors, factoring in the risks.

5.15 Pro-competitive

As long as there is ample spectrum available to the WOAN relative to the uptake from retail operators, no arbitration mechanism is needed. If, however, there is the threat that all available WOAN capacity may be booked up, the WOAN should assure the viability of non-facilities based retail operators by either reserving some portion of the available capacity for their use, or by giving their requests priority.

5.16 Regulation of relationships between the WOAN and MNOs

[51] https://en.wikipedia.org/wiki/Building_block_model

5.16.1 Regulation of availability and incremental cost based pricing of open access infrastructure, to include regulation specified pricing for:

- Roaming (WOAN-based subscriber uses other provider network where WOAN does not yet have coverage)
- Interconnection (traffic to or from other providers networks)
- Traffic termination into other providers networks)

5.16.2 The simpler the regulatory remedies, the more likely they will succeed. In Mexico, the setup of the WOAN specified that the operator Telcel could not charge interconnection fees as long as they held a >50% market share. The WOAN operator should have the discretion to deny service on the WOAN network to operators who are obstructive or unreasonable in this respect. The WOAN should also have the right to appeal unreasonable proposals to the oversight group.

5.16.3 Quality of service metrics, such as handoff success rate, should also be applied to such relationships between the WOAN and other providers based on competitive and comparable terms, monitored and enforced by the oversight group who shall have the ability to compel the supply of such quality metrics.

6 Conclusion

6.1 South Africa has unique challenges arising from both income distribution and geography that require innovative solutions, like the WOAN, to share spectrum in a fashion that achieves more than just high profits for dominant MNOs. A WOAN (Wireless Open Access Network) is both technically and economically feasible, and can enable South Africa to achieve the desired objectives of improving wireless broadband affordability and coverage.

6.2 Global experience indicates that the establishment of the WOAN must be carefully crafted to withstand the efforts of dominant incumbent MNOs, who may seek to challenge and undermine any such proposal.

6.3 The key elements to guarantee the success of the WOAN are:

- Exclusive access to new (currently unassigned) high demand spectrum, including the 3.5GHz band, with an extended concession period under a public-private partnership
- Government supported oversight to assure incremental cost based ‘open access’, especially to passive high radio site infrastructure and transport of existing MNOs, interconnect and roaming pricing, and other measures requiring the cooperation of existing mobile network operators
- A clear and stable regulatory framework to both attract investors and ensure the achievement of objectives
- Mechanisms to swiftly resolve disputes and legal challenges to the WOAN
- A pragmatic, three-phased rollout in which a rapid nationwide deployment at low cost on existing sites is the first phase:
    - Phase 1 focuses on improving affordability, performance and capacity
    - Phase 2 addresses extension of coverage
    - Phase 3 for capacity augmentation in urban areas will be needed around the 2025 timeframe.
- Ensuring the WOAN is a wholesale-only operator giving open and equal treatment to all retail service providers, with 3 key wholesale service offerings: RAN sharing, MOCN, and MVNE.
- Selection of qualified WOAN private investors, selection factors to include funding capacity and stability, access to expert staff, and independence from wireless retail operation.
- Compliance with government’s objectives and commitments made by the WOAN.

GLOSSARY

2G	2nd Generation Cellular Technology (GSM, CDMA)
3G	3rd Generation Cellular Technology (UMTS, HSPA+, etc.)
4G	4th Generation Cellular Technology (LTE, LTE-A)
5G	5th Generation Cellular Technology (3GPP r15 and beyond)
AWS	Advanced Wireless Service (Spectral Band 1695-2200MHz)
BSS	Business Support System (eg. Billing, customer care)
CU	Central Unit in a CloudRAN/vRAN architecture
DD	Digital Dividend
DSL	Digital Subscriber Line (Broadband over twisted copper pairs)
DU	Distributed Unit: Radio site located baseband equipment in a vRAN architecture
EBITDA	Earnings before Interest, Tax, Depreciation, and Amortization
ECA	Electronic Communications Act 36 of 2005 (South Africa)
ECNS	Electronic Communication Network Service
ECS	Electronic Communication Service
EIRP	Equivalent Isotropic Radiated Power (Maximum RF power exposure measure)
ePC	Enhanced Packet Core (LTE)
GB	Giga-Bytes, $1x10^9$ bytes
GDP	Gross Domestic Product
F1	3GPP standardised ‘Midhaul’ interface between a CU and DU
HDS	High Demand Spectrum (Spectrum usable for cellular, generally sub-6GHz)
IoT	Internet of Things
ICASA	Independent Communications Authority of South Africa
ICT	Information and Communication Technology
ITU	International Telecommunications Union
KPI	Key Performance Indicator
LAA	Licenced Assisted Access: Wifi linked to a cellular carrier
LTE	Long Term Evolution (4G Cellular Technology)
LTE-U	LTE in unlicenced 5.8GHz band
MEC	Mobile Edge Computing
MIMO	Multiple Input Multiple Output antenna technology
mIOT	Massive Internet of Things
MMS	Multi-media Message Service
MNO	Mobile Network Operator
MOCN	Multi-Operator Core Network
MP-TCP	Multi-path Transmission Control Protocol

MVNE	Mobile Virtual Network Enabler (Provides infrastructure for MVNO)
MVNO	Mobile Virtual Network Operator (Retailer)
NB	Narrow Band
NBN	National Broadband Network (in Australia)
gNB	Next-generation (5G) Node B
NGC	Next-Generation (5G) Core (also supports LTE packet core functions)
NR	New Radio (5G Air Interface)
OSS	Operation Support System (eg. Network management)
PON	Passive Optical Network
PPP	Public-Private Partnership
PRB	Physical Resource Block
POI	Point of Interconnect (between two network operators)
QoS	Quality of Service
R	Rand, unit of South African Currency
Rx	Radio Receive Path
RSA	Republic of South Africa
SA	South Africa
SMME	Small Medium and Micro Enterprises
SMS	Short Message Service
TRX	Radio element (transceiver) to receive and transmit signals
Tx	Radio transmit path
UFB	Ultra-fast Broadband; a fibre based broadband service in New Zealand
urLLC	Ultra-Reliable Low Latency
USAF	Universal Service and Access Fund (South Africa)
vRAN	Virtualised and Centralised Radio Access Network aka CloudRAN
WOAN	Wireless Open Access Network

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Appendix A

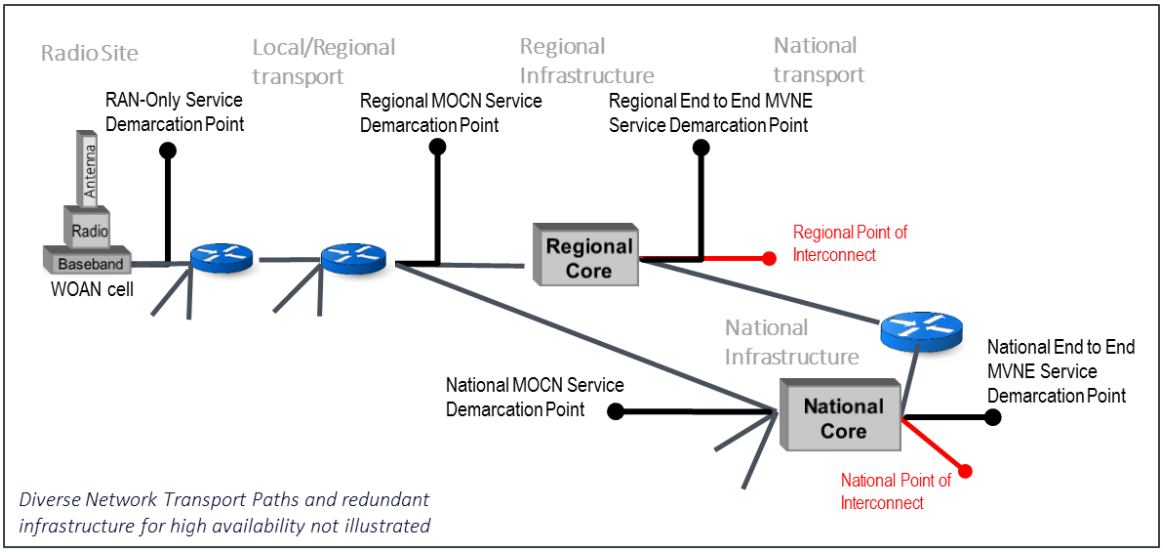
Technical Description of Phase 1 WOAN deployment

The objective in Phase 1 is to provide the maximum performance and coverage that can be achieved rapidly and at minimum cost (to support affordability objectives while making the WOAN sustainably profitable. In addition to open access to infrastructure elements, the WOAN will offer 3 wholesale services: RAN Sharing, MOCN, and MVNE. (Technically, the RAN Sharing option is also a MOCN like architecture, but without transport)

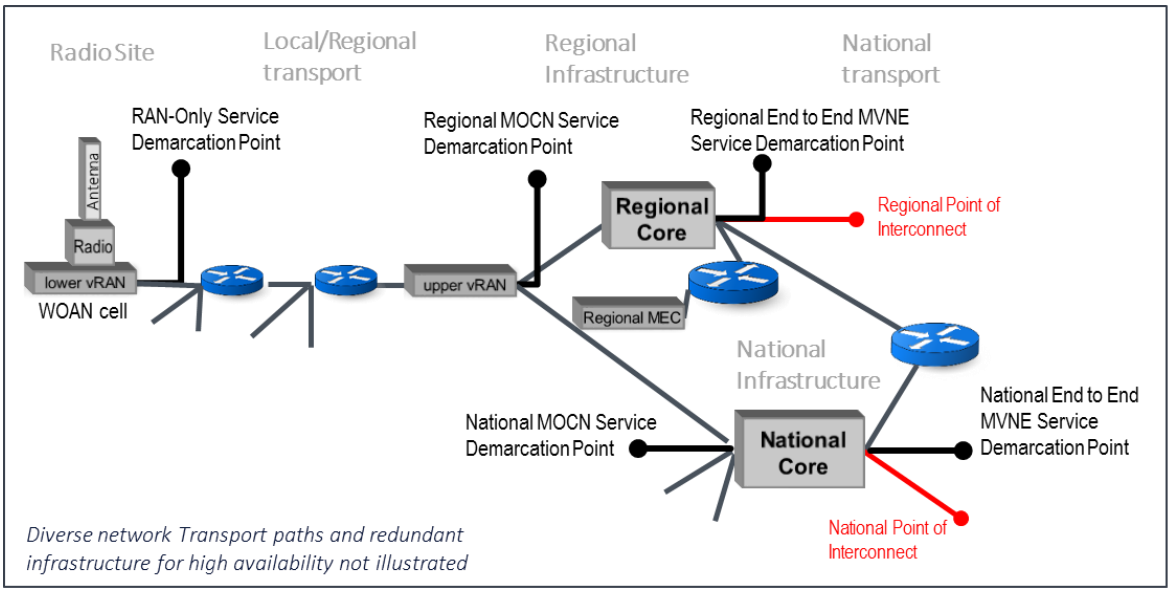
WOAN services and customers

Wholesale Service→	RAN Sharing	Regional/National MOCN	MVNE
Key Customers	MNOs: MTN, Vodacom	MNOs: Cell C, Telkom Mobile	MVNOs
Role of WOAN	• Active RAN: Shared use of WOAN provided spectrum/ antenna/radio/ baseband	• Active RAN, • Regional/National transport	• Active RAN • Regional/National transport • Packet Core • Network operations, • Interconnect/roaming
Role of WOAN Customer	• Regional/National transport • Packet Core • Network operations, • Interconnect/roaming • Customer operations • Sales and marketing	• Packet Core • Network operations • Interconnect/roaming • Customer operations • Sales and marketing	• Customer operations • Sales and marketing
Differentiation for WOAN Customer	• Network Quality • Network service definition • Pricing • Customer Service Quality • Marketing	• Network Quality • Network service definition • Pricing • Customer Service Quality • Marketing	• Pricing • Customer Service Quality • Marketing

These service offerings are shown in the following network architecture drawings, in both the traditional classic distributed baseband configuration, and the emerging virtualised cloud RAN configurations (vRAN).



WOAN overall architecture with fully distributed baseband



WOAN overall architecture with vRAN

The vRAN architecture has greater flexibility in scale, supports rapid introduction of new features, and multiple inter-site coordination functions such as multi-connectivity and application aware quality handling. However, the 'midhaul' connection (also referred to as fronthaul) in vRAN architectures

requires stricter latency and jitter in local/regional transport which may not be cost effectively available in all areas. Classic and vRAN architectures may be mixed with the WOAN network.

Role of suppliers to WOAN

- Active network equipment (Purchase): Antennas, radios, baseband, packet core
- RAN installation and commissioning (Sub-contractors)
- Access to existing passive network assets- towers, powering, feeder cables, enclosures (lease only in Phase 1)
- Access to wholesale transport (lease)
- Network Operations systems (Purchase)
- Interconnection and roaming arrangements (negotiated)

WOAN Cell site infrastructure

Cell site configuration

Phase 1 will employ, under 'open access' rules, selective existing sites from MTN, Vodacom, Telkom, Cell C, Rain, and tower companies including existing passive cell site infrastructure including powering, enclosures, fronthaul feeder fibres, and towers/masts. The Open Access regime should clearly specify costs of access in such a fashion that providers cannot 'game the system' by loading in additional cost elements.

In some cases, enhancements to existing facilities may be required such as:

- Augmenting microwave transport links
- Tower strengthening for weight and wind-load
- Expansion of enclosure space
- Expansion of power backup capacity (battery, diesel generator)

New equipment configuration and setup at each suburban/rural radio may include:

- 3 sectors of 700+800 MHz Antennas (possibility of 4x4 for enhanced reach),
- New Low band radios as follows, nominally with support for 7 carriers per ICASA proposal[52]:
    - 2Tx-2Rx (or 4Tx-4Rx)
    - Any given carrier may be used with either LTE or 5G NR air interfaces
    - Carriers must be convertible from LTE to 5G NR air interface through remote software configuration

[52] The WOAN implementation may choose different frequency segmentation subject to guardband restrictions, max 20MHz LTE carrier width, etc. For example, the spacing for intra-band carrier aggregation defined by 3GPP specifications would preclude a 20+10 or 15+15 configuration in the 700 MHz band. In a 10+10+10 configuration, the two (2) extreme blocks could be combined; however, so far, intra-band carrier aggregation for either 700 or 800, or inter-band aggregation between the two bands has not been considered by 3GPP.

    - Carriers may support simultaneous operation of LTE and NR in a shared carrier
- In addition, high-load sites (eg. Urban) will add Radios and Antennas for 3 sectors in 2600MHz band, with 8x8 MIMO supporting up to 5 additional carriers with 2x70MHz of spectrum.
- New baseband equipment
    - Baseband capability may be integrated with radio or hardened outdoor mast/tower mount (no enclosure or heating/cooling required)
    - Architecture may be fully distributed (Classic BBU) or 'Cloud Optimised' high layer split (3GPP Option 2, RLC-PDCP split)
    - Baseband must support simultaneous LTE and 5G flexibly assigned to air interfaces.
    - Retail service providers must be able to specify which carriers they want to use (especially 700/800 vs 2600 MHz)
    - Retail service providers (more particularly MNOs) should be able to purchase capacity within one or more carriers in any of 3 modes of air interface capacity sharing:
        - Dedicated PRBs per provider
        - Block of PRBs shared equally amongst multiple providers
        - Shared PRBs with priority (unequal sharing)
        - Many retail service providers may share a single air interface
        - A single provider may purchase more than one mode simultaneously at a site, eg. a block of dedicated capacity plus some shared capacity for peaks.
    - Supports at least 6 x 20 MHz carrier aggregation
    - Supports 4x4 MIMO at 700/800 MHz carriers and 8x8 MIMO at 2600 MHz

All Phase 1 regional transport infrastructure will be existing and will be leased from existing infrastructure owners, such as OpenServe, or MTN/Vodacom under open access rules.

Transport should be purchased at OSI L2 (Ethernet) and/or L3 (IP). The traffic belonging to separate operators purchasing at a MOCN model must be separated in transport (eg. VLAN separation) and different retail service providers may choose to interconnect to their core networks at more or less distributed points of interconnect. (RAN-only customers of the WOAN will provide their own transport, and E2E/MVNO customers will share transport capacity to a shared core network.)

The WOAN and leased wholesale transport providers will negotiate standard SLAs such as:

- Throughput
- Packet error rate
- Packet Delay (latency)
- Packet Delay variation (jitter)
- Availability (unavailable minutes)
- Reliability (Number of outage events exceeding threshold)

Very similar requirements will exist with respect to SLAs which the WOAN will offer to retail service providers to guarantee quality of the wholesale service offered.

Finally, Phase 2 will involve new cell sites, which will in turn require new transport infrastructure.

WOAN Regional infrastructure

Regional centres may be more or less distributed; 100s of small regions) or less (~a dozen large). A more distributed approach will lend itself to localised retail operators, e.g. providing fixed wireless access to a small town, and will also allow for better control over transport latency and jitter for 'midhaul' in a high layer split virtual RAN. A more centralised approach will better suit national operators and fully distributed BBUs with 'backhaul'.

At each regional centre there will be two or more physical instantiations of virtual edge cloud functions (for redundancy) which will include, at a minimum, packet core functions, but may also include virtualised and centralised RAN functions such as multi-connectivity and application specific traffic handling. The virtual edge cloud may also support Multi-Access Edge Cloud (MEC) functions such as hosting of latency sensitive content and applications.

The packet core functions must support:

- Multiple virtual operators sharing common core (eg. Many retail service providers)
- Both LTE ePC and 5G NGC functions (especially 5G network slicing)
- Standalone (SA) and non-Standalone (NSA) scenarios

WOAN Points of Interconnect with Retail Customers

Interconnection has two dimensions, the points where a retail service provider connects to the WOAN, and the places that the WOAN connects to other networks in delivery of an end to end wholesale network. The following points of interconnect will be defined between the WOAN and a retail customer:

- RAN-Only: Retail service provider connects to physical radio site baseband transport interface supporting the following logical connections:
  - Operations and Maintenance OSS connectivity to radio site located equipment including configuration, software updating, fault detection, Self-Optimizing Network (SON) functions, reporting and statistics
- And optionally:
  - Connections between regionally centralised vRAN CU (central unit) and a radio site located DU (distributed unit) (eg. per F1 interface)
- Followed by:
  - Connection from logical RAN baseband (centralised or distributed)
    - LTE connections to core: S1-U, S1-MME
    - LTE connections to other eNBs: X2
    - 5G connections to core: N2, N3
    - 5G connections to other gNB: Xx, Xn

WOAN National transport infrastructure

Especially if regional networks are small, there will be significant value to national scope retail service providers to have a shared and managed network backbone providing national connectivity, eg. Johannesburg to Cape Town. This allows the WOAN to keep inter-region traffic within the WOAN network, avoiding interconnection costs. As the WOAN picks up an increasing proportion of subscribers, it will also allow inter-retailer traffic between points that are WOAN attached from needing to pass through interconnect points as well.

WOAN Points of Interconnect with Other Networks

On the first day of operation, the WOAN will have no networks in place and even with open access rules in place it will take years to grow the WOAN to cover a large proportion of population and sites. Thus, a roaming agreement with other providers is essential to enable nationwide coverage for MVNO style retailers.

Other critical elements of such interconnection include call handoff, traffic termination, traffic transit, and overflow. Regulatory oversight should govern availability, quality/performance, reliability, pricing, fault restoration KPIs, and other attributes of the interconnection.

Appendix B

Impact of the WOAN on Urban Demand

This annexure provides a high-level and preliminary forecast estimate, which must be further refined, of the incremental infrastructure a 'typical' mobile operator will need to deploy with existing spectrum holdings, and in parallel the amount of spectrum needed to meet traffic demand up to 2030. No distinction is made in respect of the type of additional sites (small cells, multi-sectoring etc.) nor between population categories who may or may not afford a high-volume subscription. Focus is on human demand only. The projected mobile broadband demand per subscriber is derived from:

- Past mobile traffic consumption in South Africa (e.g. GB/month /sub for 2011-2016 period[53]),
- Benchmarks from analysts' forecasts[54]

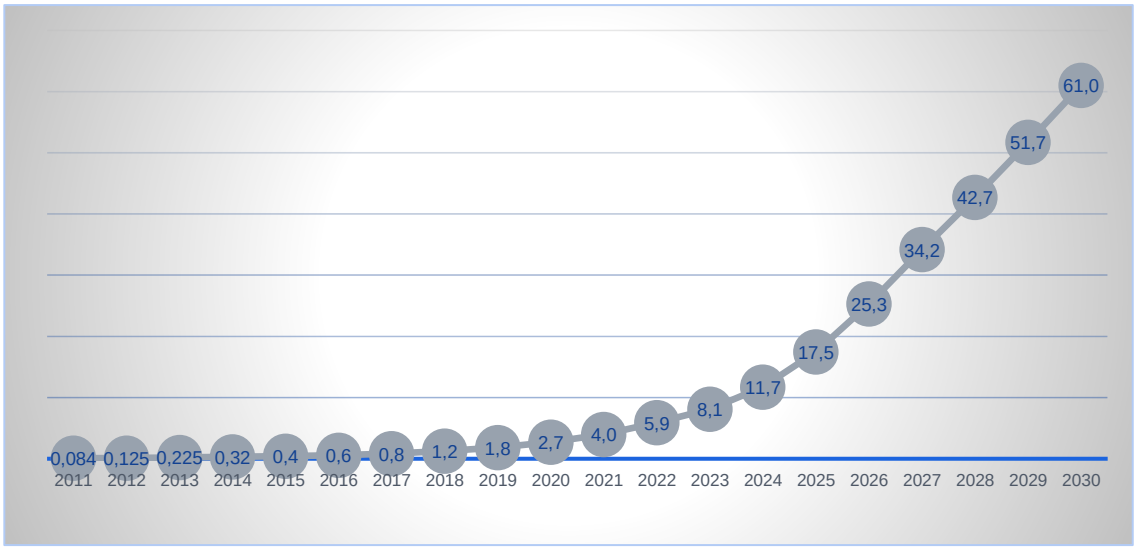


Figure 1: Growth estimate of average mobile demand per user (in GB/month)

Average traffic demand starts at 84 MB/month/sub in 2011 and reaches 61 GB/month/sub in 2030. While there would be a mix of devices the assumption is that smartphones, tablets, wearables etc. will be the norm. Given that MNOs have WiFi data plans offerings it is not clear whether the reported demand refers to traffic carried over 3G and 4G only[55]. Throughout, it is assumed that the above demand does not include WiFi off-loading. Further, there is no accounting for traffic that could be

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[53] https://mybroadband.co.za/news/cellular/133090-the-massive-rise-of-mobile-data-in-south-africa-in-5-charts.html ; GSMA RSA Stats 2017

[54] CISCO VNI https://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/#~Country

[55] This is also contingent on the degree of integration between the WiFi and MNO networks. The buildout of a WiFi network, however limited in coverage, or the acquisition of a WiFi provider cannot be excluded. Nevertheless, despite the lack of QoS implementation, short range etc. offloading to the nearest WiFi node is an approach MNOs will take to make up for new spectrum

generated by other than traditional consumers as the WOAN may serve vertical segments whose endpoints could be both humans and machines.

Therefore, it is assumed that:

- The mobile broadband traffic is supported by LTE throughout the 12-year period. Although 5G will be expected to appear in the market place in the early to mid-twenties, we believe that the 3.5 GHz may be more appropriate than current mobile spectrum because of the projected larger eco-system. Possible 3.5GHz band and 3.3-3.4GHz bands have been excluded from the spectrum sizing figures used here.
- Spectral efficiency gains are expected over time (at least until the emergence of a mature 5G portfolio or until 2026),
- The 3G network would experience shutdown with legacy spectrum refarmed to LTE
- A 5MHz bandwidth is reserved for minimal 2G services by each major incumbent (eg Vodacom, MTN, Cell C); most likely in the 900 MHz to maintain services in rural areas
- The WOAN will be allocated 55 MHz from both 700 and 800 MHz bands and another 70 MHz in high spectrum band like 2.6 GHz. (excluding current Neotel 2x5MHz)
- We estimate that the largest number of existing urban/metro sites that that will be needed to provide contiguous coverage is <5,900 (there are some urban sites today for capacity densification).

Firstly, spectrum is considered which would be needed to support the urban population with the radio infrastructure estimate assuming all those sites belong to a single ‘operator’, with the potential to use all spectrum bands currently licenced to MNOs, or 116 MHz. With the assumed forecast traffic demand model and site count (without site growth), the total spectrum need for 2030 amounts to 1,183 MHz/site. From 2026 onward, the demand cannot be supported by the infrastructure unless the site count is increased or, new spectrum is injected into the system. Par YE2025, the need for 262 MHz/site cannot be met by the aggregate spectrum (ie 241 MHz resulting from 116 MHZ refarmed MNOs spectrum + 125MHz WOAN spectrum) at each site. The spectrum situation is summarised in the following table.

Spectrum (MHz)	700+800	900	1800	2100	2600	Total (MHz)	Usable w/ refarming + keeping 2G
VDC		11	12	15		38	33
MTN		11	12	15		38	33
Cell C		11	12	15		38	33
Rain			10			10	10
Telkom			12			12	7
MNOs Total Spectrum		33	58	45	0	136	116
WOAN Spectrum	55				70	261	**241**

Spectrum holdings and estimates of available MNOs usable spectrum

Since voice is a critical service, and pending migration to VoIP over 4G, it is assumed that every MNO with 900 MHz spectrum licences maintain 5 MHz throughout the period considered. If we were to consider 2G shutdown, the usable 4G spectrum will consist of 136 MHz; such spectrum would serve 4G customers but also machines (e.g. with NB-IoT).

	2017	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*2027*	*2028*	*2029*	*2030*
RSA Population (in million)	56.5	57.7	58.9	60.1	61.3	62.6	63.9	65.2	66.5	67.9	69.3	70.7	72.2	73.6
Urban/Metro Population (61%)	34.5	35.2	35.9	36.6	37.4	38.2	39.0	39.8	40.6	41.4	42.3	43.1	44.0	44.9
BB Adoption	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
GB/month /Sub	0.8	1.2	1.8	2.7	4.0	5.9	8.1	11.7	17.5	25.3	34.2	42.7	51.7	61.0
DL traffic %	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Load	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
Required Network Bandwidth (GH	316	464	681	975	1,400	2,014	2,623	3,626	5,413	8,011	11,037	14,080	17,388	20,941
Number of Urban Sites	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900
Number of ksubs/site	5.84	5.96	6.08	6.21	6.34	6.47	6.60	6.74	6.88	7.02	7.16	7.31	7.46	7.61
Bandwidth need per Cell (MHz)	18	26	38	55	79	114	148	205	306	453	624	796	982	1,183

The following scenarios describe in simple terms why a wholesale operator makes sense from a spectrum utilisation perspective. When lacking adequate spectrum, and absent new capacity enhancing features, mobile operators have no option but densify their network to meet demand. Had we analyzed individual MNOs and their subs in terms of market share, the outcome would be the same.

- The ‘operator’ re-farms 33 MHz of spectrum for LTE while keeping 5 MHz for 2G. The traffic demand can be met until YE2021, after which the site count must grow up to 14 times by YE2030 (blue curve in the figure below); this is certainly an unrealistic scenario
- The ‘operator’ refarms 33 MHz of spectrum for LTE, while keeping 5 MHz for 2G, but buys an additional 30 MHz bandwidth. Existing infrastructure can meet the demand but by YE2023 new sites are needed, with up to 7x the number of sites by YE 2030 (red curve in the figure below)
- With a WOAN operator with 125 MHz to wholesale and the ‘operator’ re-farming its legacy spectrum, there is an aggregate of 241 MHz available. But beyond 2024, new sites would be required in order to meet the projected demand to 2030 (green curve in the figure below).

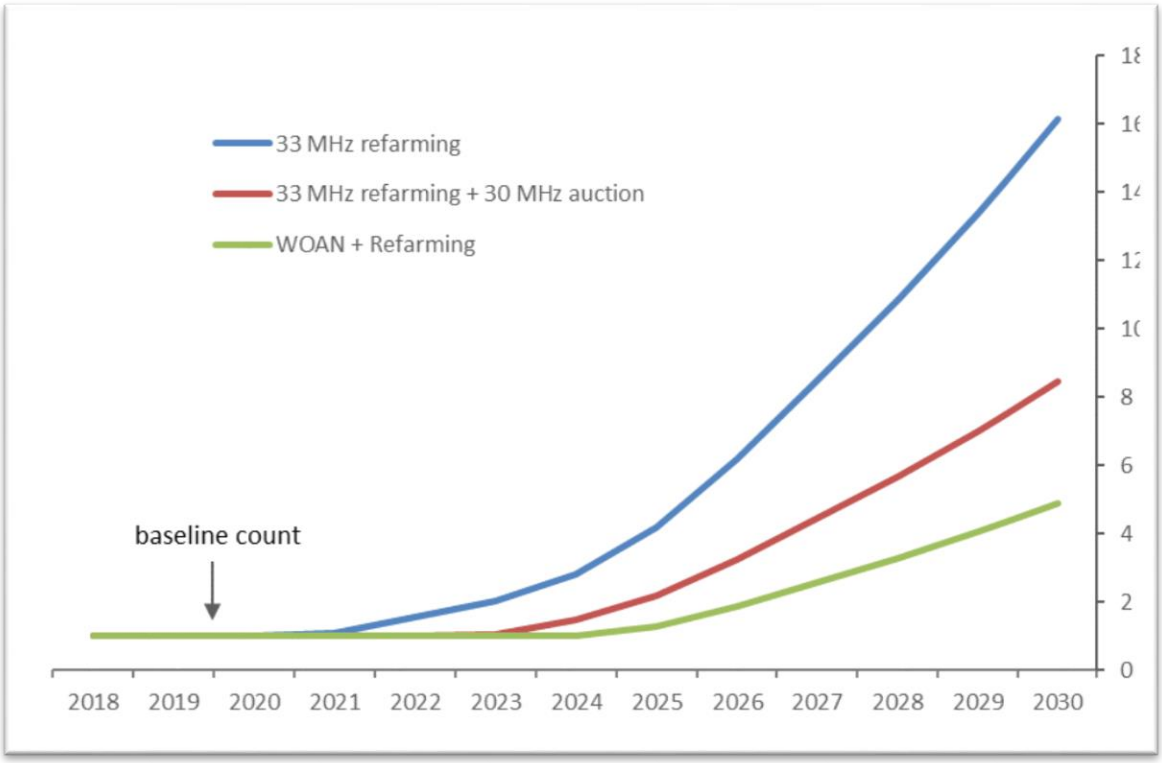

Figure 2: Required incremental site increase to meet future mobile broadband demand

The WOAN delays the need for site densification by at least 2 years and dramatically decreases the number of sites to be deployed at the end of the study period.

On top of these savings, urban traffic support is the mandatory condition for the WOAN sustainability, in order to make up for rural coverage low profitability. This quick and highly conservative study does not take into account 5G launch which would impact the analysis in view of a better spectral efficiency; this is tributary of the future of high band spectrum such as the 3.5 GHz (180MHz) and the higher millimetric waves. (26, 28, 39GHz…). Similarly, it does not account for WiFi offloading which would reduce the capacity strain on the mobile infrastructure.

Appendix C - Rough WOAN economic viability model

A crude approximation of the potential for the WOAN to be profitable, and therefore attract private investors can be performed by taking publicly available financials of a South African MNO. Based on the extent of their network, we have elected to use the financials of MTN and extrapolated what the equivalent financials would look like for a WOAN operating at the same scale as MTN (end of Phase 1 build-out).[56]

The 2016 Financials of MTN South Africa are shown on the left column. Although we accept that this was not a representative year for MTN as a whole, due to events in Nigeria, it seems like an average year for the MTN South Africa.

Financials for the WOAN simulate two sales models, “RAN sharing’, e.g. for sales to MTN, Vodacom or Cell C, and “MVNE” for sales to MVNOs, are displayed in the columns to the right.

Adjustments are as follows:

1. Though the WOAN might initially support a number of application classes (voice and SMS/MMS, browsing, streaming video, file transfer, public protection and disaster recovery), for the purposes of this model, they are removed and the focus on data.
2. RAN sharing is assumed to account for 25% of retail revenue and the MVNE (end to end wholesale service) is assumed to account for 50% of retail revenue.
3. Interconnect and roaming costs are assumed to reflect the share of data revenues as compared to data+voice+SMS: 42% for MVNE. For RAN Sharing, the MNOs are responsible for such costs and functions themselves. This is conservative, especially if the government legislates interconnect and roaming charges
4. WOAN network operating costs are assumed to be 50% lower for MVNEs; this would be mostly open access fees paid to other providers for sites, towers, power, etc. It is assumed that in the case of a RAN-only service, each MNO is responsible for its own transport and packet core and network costs which are therefore assumed to be 70% lower.
5. The WOAN has no retail presence, therefore no costs have been attributed to MVNO marketing, and commissions, revenue sharing, discounts, etc.
6. The WOAN has very lean staffing (RAN build being capitalised, so staff cost includes maintenance, network management, and other SG&A), this is therefore assumed to be equivalent to 20% of MTN staffing and ‘other OPEX costs’

[56] This is a single year snapshot. The analysis can be enhanced to examine the progression over time.

High-level Economic Viability model

MTN South Africa 2016 Results			WOAN		WOAN (RAN Only
REVENUE BREAKDOWN	**(Rm)**				
Country	**YTD16**	% of…			
South Africa					
Outgoing voice	**16,949**				
Incoming voice	**1,577**				
Data	**14,162**	**50%**	7,081	25%	3,541
SMS	**1,312**				
Devices	**7,046**				
Other	**876**				
Revenue	**41,922**		**7,081**		**3,541**
COSTS					
Country	**YTD16**				
South Africa					
Handsets and other accessories	**9,701**				
Interconnect	**2,771**	**42%**	1,154		-
Roaming	**330**	**42%**	137		-
Commissions	**1,929**				
Government and regulatory costs	**142**		142		142
VAS/Digital revenue share	**539**				
Service provider discount	**1,928**				
Network	**4,110**	**50%**	2,055	30%	1,233
Marketing	**1,041**	5%	52	0%	-
Staff costs	**2,366**	**20%**	473.20	15%	354.90
Other OPEX	**3,255**	**20%**	651.00	15%	488.25
Cost	**28,111**		4,664.91		2,218.15
EBITDA	13,811		2,416.09		1,322.35
EBITDA/Revenue	33%		34%		37%