## Executive Summary

The economic competitiveness of regions depends on good connectivity, broadband network development plays an important role in strategic policies to promote growth and innovations in all sectors of a given economy. Broadband penetration is attributed to increased income and reduced unemployment via opportunities for remote work and the ability to expand brick and mortar enterprises online. Studies suggest that a 10% increase in broadband access results in a 1.2% GDP growth in developing economies (Qiang).

Over 2.5 billion people - more than 30% of the planet's population live in rural and remote areas of developing countries according to an International Telecommunication Union (ITU) report. Strong digital connectivity is vital for ensuring the future of rural communities and allowing them to thrive just as much as urban areas. It provides access to opportunities in tele-healthcare and education, cutting down lengthy travel times. Rural broadband access also makes homeworking a viable option for many which can encourage more people to live and work in these regions preventing brain drain.

Exponential growth in mobile networks' data traffic has led to a significant increase in electricity usage and operational expenditures of mobile network operators. Studies report ICT network operators consumed 1.15% of the total electricity grid supply globally and contributed to 0.53% of the global carbon emissions related to energy (Ericsson).

For network operators to run a sustainable commercial model especially in rural/remote areas, there has to be a paradigm shift in network deployment architecture. Orb is specifically designed to create a series of interconnected network stations outside of existing operator serving areas, extending service from the closest Base Station (BS) to the rural vicinity. This mesh of network nodes would act as bridging devices, able to relay network services onto one another.

## Introduction

Broadband is a key priority in the 21st century, it is an essential tool for empowering populations due to its transformative power as an enabler for economic and social growth. Broadband penetration can lead to increased income and reduced unemployment via opportunities for remote work and the ability to expand brick and mortar enterprises online.

A report published by the Public Accounts Committee (PAC) has lambasted the Government for the failure of its broadband strategy, pointing out that it is unlikely even to meet its revised 2025 target, which excludes 15% of the UK's population, mostly in rural areas.

Gigabit broadband was a central plan of the Government’s strategy in the run up to the General Election in 2019. Before the election, in September 2019, Prime Minister Boris Johnson committed to every home having a gigabit internet connection by 2025, and a fund of £5 billion to help pay for it.

In July 2020 that pledge was watered down to ‘best effort’, and only a quarter of the funding will be released this Parliament, which could run until late 2024.

In November 2020, after the country’s absolute reliance on connectivity for all spheres of activity as the UK entered its second lockdown, the Government published its National Infrastructure Strategy which promised gigabit coverage to 85% of the country by the end of 2025.

With this backdrop, Orb is a proposed solution to address three fundamental challenges that limit broadband coverage in rural and remote regions (base stations, backhaul and power). It is a user hosted device with TV whitespace/5g backhaul conceived to shift the cost of deploying networks from operators solely to a shared model (User-operator). In this context of this study, rural and remote refers to isolated and poorly served areas by telecommunication facilities. We also aim to integrate this with renewable energy services to curb carbon emissions from increased energy demand of mobile network operators as a result of the inevitable increase in demand for services.

## Challenges of Rural broadband

In this document the expression “Rural and Remote” (or just “Rural”) refers to rural, isolated, and poorly served areas by telecommunication facilities, where various factors interact to make the establishment of telecommunication services difficult.

Rural and remote area are generally sparsely populated and hard to reach thus associated with some challenges and misconceptions by Mobile Network Operators (MNOs). Technically the main barriers to rural coverage verified by figures 1 and 2 respectively are – base stations, backhaul and power.

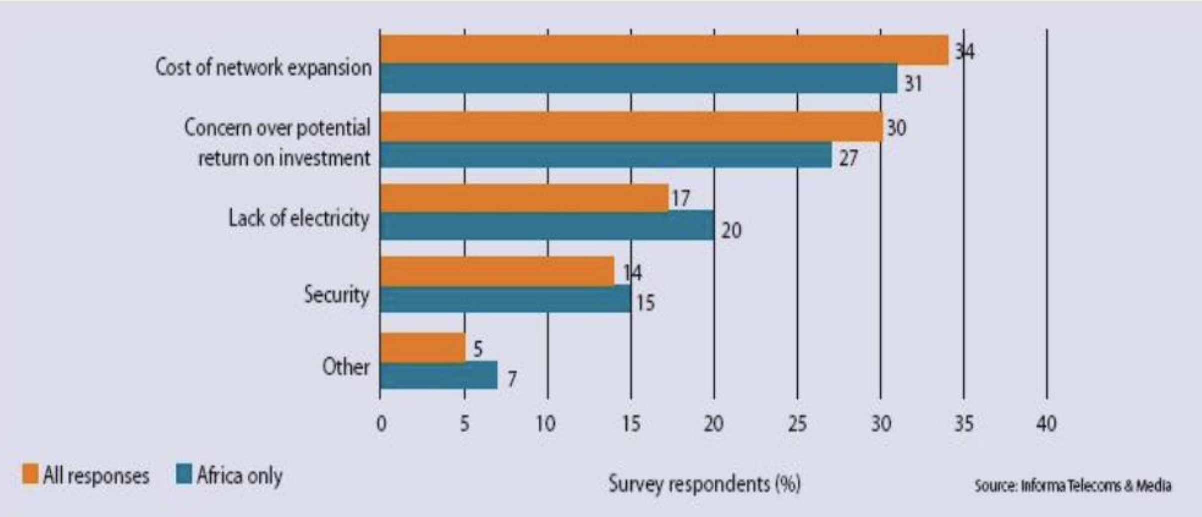


*Figure 1: Survey on MNOs biggest barriers to infrastructure expansion into Rural areas ([Bright et al](#))*

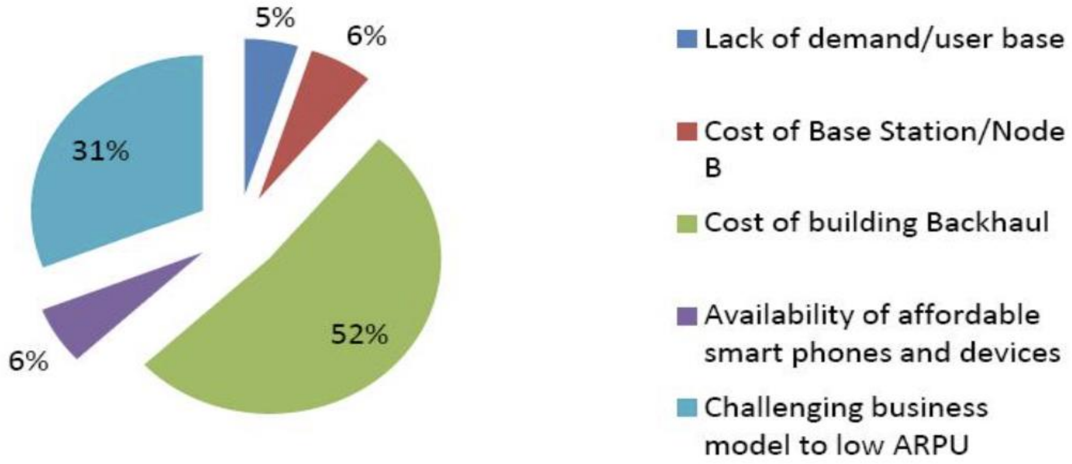


*Figure 2: Operators Perceptions on Different Factors hindering Rural Connectivity ([Bright et al](#))*

The cost and complexity of deploying multiple macro base stations to rural/remote areas is quite significant and often does not correspond to the revenue profile of these sparsely populated areas. Also, amplified by absence from gateways, switches and fibre networks.

Backhaul and installation costs are critical issues to consider when deploying multiple cells for extended coverage. Due to the cell size shrinkage and increasing number of radio access points required. Diverse backhaul strategies are essential to accommodate dense base stations.

Lastly, power consumption of multiple macro base stations is quite enormous and even more so for developing nations where Mobile Network Operators (MNOs) rely on diesel generators for reliability, although renewable sources are becoming more attractive.

Addressing these three major challenges, highlighted above, is a step wise direction in our goals for addressing rural broadband.

## Market.

Over 2.5 billion people - more than 30% of the planet's population live in rural and remote areas of developing countries according to an International Telecommunication Union (ITU) report. Strong digital connectivity is vital for ensuring the future of rural communities and allowing them to thrive just as much as urban areas. It provides access to opportunities in tele healthcare and education, cutting down lengthy travel times. Rural broadband access also makes homeworking a viable option for many which can encourage more people to live and work in these regions preventing brain drain.

Certain effects can be derived as the economic impacts of broadband (figure 4). The first results from broadband network construction. Creating jobs and acts over the economy by means of multipliers. The second effect results from the "spill-over" externalities, which impact both enterprises and consumers. The adoption of broadband within firms leads to a multifactor productivity gain, which in turn contributes to growth of GDP. On the other hand, residential adoption drives an increase in household real income as a function of a multiplier. Beyond these direct benefits, which contribute to GDP growth, residential users receive a benefit in terms of consumer surplus, defined as the difference between what they would be willing to pay for broadband service and its price. This last parameter, while not being captured in the GDP statistics, can be significant, insofar that it represents benefits in terms of enhanced access to information, entertainment, and public services.

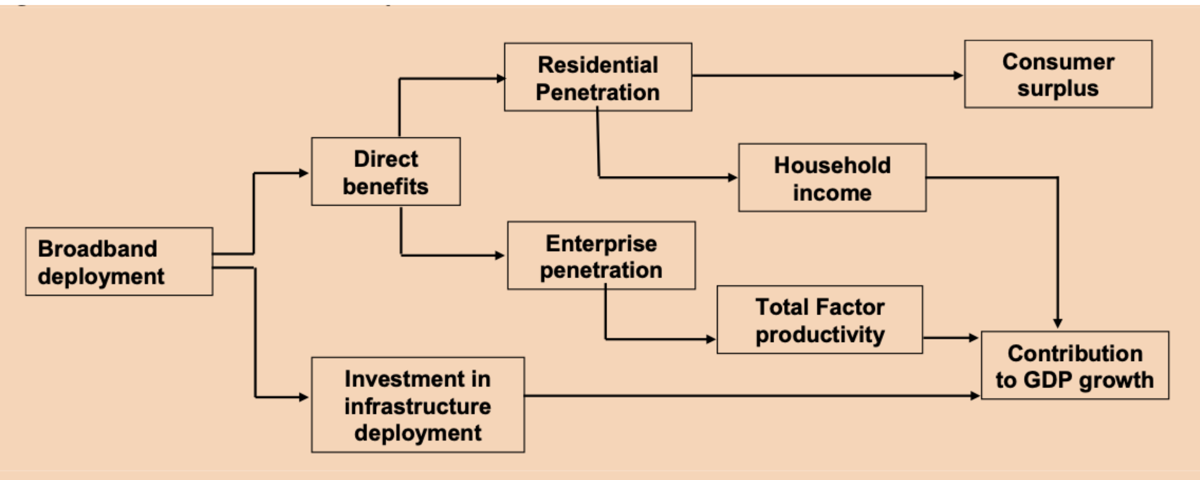


*Figure 3: broadband economic impact (ITU 2012)*

Current levels of broadband and mobile phone provisions in rural areas are stifling innovation. There are economic and environmental benefits of connecting rural communities especially for the delivery of a sustainable and productive agricultural sector.

There have been calls on the government by the National Farmers Union of England and Wales (NFU) to keep its commitment to make the UK the best-connected country in the world. Farmers need superfast broadband and reliable mobile connections. Figure 4 presents a survey by the NFU depicting the current challenges of rural households and farmer in the UK. Some travel over 5 miles away from their farms to get a reliable mobile signal. Sometimes they go hours or days without connection, or an average have between 0.3 and 0.6 Mbps. This limits their ability to attract tenants to their converted shed offices.

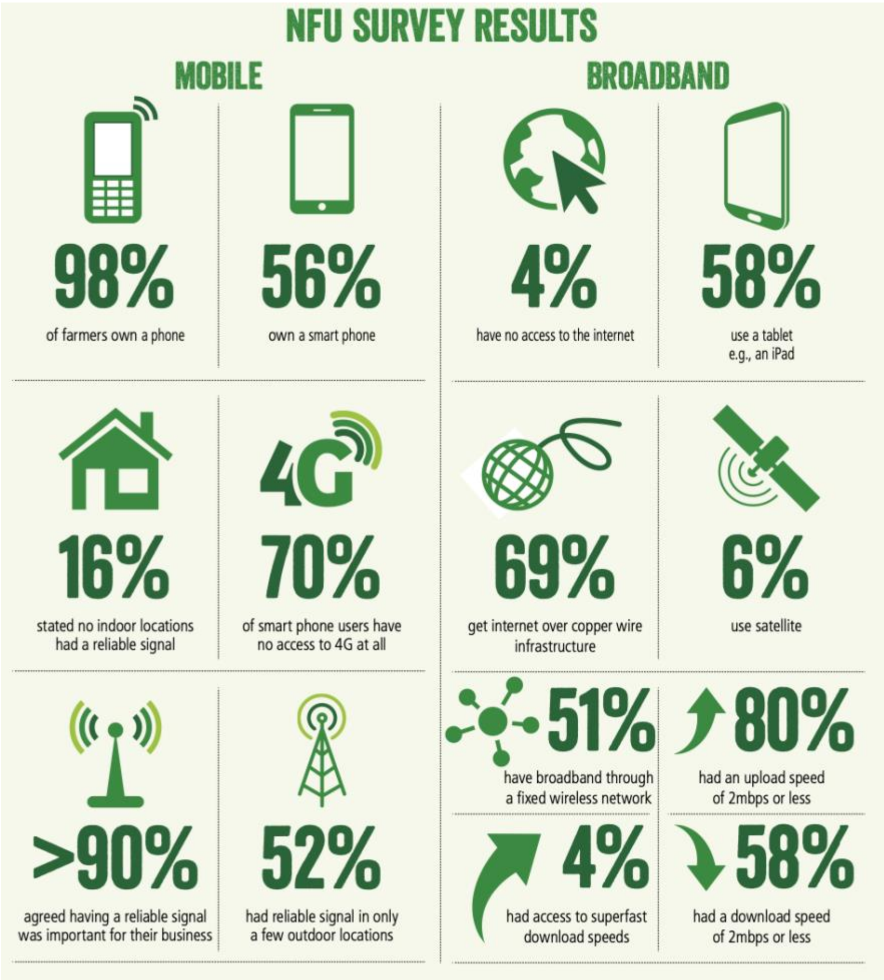


*Figure 4: NFU survey report for broadband coverage (NFU)*

It is important to note that the excluded population in the UK can be likened to the 20% in the USA, 30% in the EU and over 60% in sub-Saharan Africa. Developing a solution to broadband has never been more critical in order to bridge the economic inequalities of regions.

# Technology

Orb is a user hosted small cell (Pico) with self-sustaining power requirements and TV whitespace backhaul. A small cell is a radio access point with low radio frequency (RF) power output, footprint and improved range. It is operator controlled and can be deployed indoors or outdoors and in licensed, shared or unlicensed spectrum to complement macro networks (cell towers) by improving coverage. There are various types of small cells with varying range power level and form factor (table 2). Typically, small cells range from indoor-based residential/enterprise femtocells, picocells/microcells, to macro cells which are the traditional base stations mounted on cell towers with high power consumption and cooling requirements.

*Table 1: Type of Small Cells*

| **Cell Type** | **Output power** (W) | **Cell Radius** (Km) | **Users** | **Locations** |
|---|---|---|---|---|
| Femtocell | 0.001 to 0.25 | 0.01 to 0.1 | 1 to 30 | Indoor |
| Pico cell | 0.25 to 1 | 0.1 to 0.2 | 30 to 100 | Indoor/Outdoor |
| Micro cell | 1 to 10 | 0.3 to 2.0 | 100 to 2000 | Indoor/Outdoor |
| Macro cell | 10 to >50 | 8 to 30 | >2000 | Outdoor |

Small cells like the Orb can also provide additional benefits for network operators for capacity enhancement and coverage extension, which can be generally classified but not limited to the following: Providing additional capacity at a high-traffic location (hot-spot), offloading traffic from a congested macro-cell, providing higher capacity and performance at the edge of a macro-cell, extending coverage at the edge of the network and into isolated or remote areas.

Sitigrid's Orb connects to the nearest macro cell (tower) some distance away via TV whitespace (TVWS), 5g or LTE backhaul eliminating huge capital expenditure on fibre deployment. Orb is a user subsidised radio equipment splitting the cost of the network between the Operator and the user.

TV whitespace (TVWS) provides long-range cost-effective solution to broadband connectivity. TVWS is an example of spectrum sharing, currently used to connect rural communities to the internet around the world. It is the name given to unused broadcasting frequencies in the wireless spectrum or gaps left between channels by TV networks. Given the appealing characteristics of TVWS frequencies, it has a number of potential use cases such as rural broadband, campus networks (AKA 'super Wi-Fi) and connecting IoT devices.

## Alternative solutions

The introduction of Time Division Multiple Access (TDMA) systems has been a major driver in the use of satellite for small cell backhaul because it enables a cost effective sharing of bandwidth resource pools by many sites. Examples include Eutelsat's Ka satellite with multiple spot beams over Europe, ViaSat- 1 and EchoStar XVII, which provide more than 100Gbps of capacity, over 100 times the capacity of traditional Ku FSS Satellites. Appropriate encryption and security measures have also been introduced to prevent Quality of Service (QoS) degradation due to security processing, such as IpSec, and other TCP/IP performance enhancement schemes (Maral et al).

**K-Net** combines iDirect Satellite backhaul with Alto bridge Small Cells to provide connectivity in rural and remote areas of West and Central Africa, supporting MTN, Vodafone, Tigo. It has lowered TCO by up to 65% compared to traditional backhaul service.

**Rural Star:** Huawei technology which enables three transformations: transforming microwave or satellite transmission in traditional solutions to Relay, substituting simple poles for towers, and enabling a move from diesel generators for power supply to solar power thereby shortening the return on investment (ROI) period for mobile communications in remote rural areas. Operators can then lower the threshold of profitability by 50%. The solution has been successfully deployed by 12 operators in eight counties, including Nigeria, Thailand, Ghana, Indonesia, and Mexico (figure 6). It won the GSMA award for "Best Mobile Innovation for Emerging Markets" in year 2018.

Satellite backhaul is insensitive to distance or terrain, allowing multiple sites to be connected quickly and without prior infrastructure. HTS and TDMA allow frequency re-use by spot beams and dynamic bandwidth allocation and sharing on-demand. With such solution, MNOs are only paying for the satellite bandwidth that they need, and serving customers that they target, using infrastructure that is likely to pay for itself in weeks or months, rather than years (Madeline et al).

*Figure 5: Rural Star 2.0 Small Cell in Nigeria and Small Cell in Ghana respectively (L: R)*

## Revenue Model and Strategy

Our primary customers are Network Operators seeking to extend their coverage and municipalities willing to participate to improve members services. Recently there has been a major push for municipality networks in the UK driven by the gigabit broadband scheme. Our revenue projections (table 2) assume a device sale price of ~£300 (with a 5% margin) and a recuring service charge of £45 with a 10% margin.

*Table 2: Orb's revenue projection*

| Revenue Projections | | | | | | |
|---|---|---|---|---|---|---|
| | Trials & Pilots | | Beachhead | | Launch | |
| **Cost stack** | **2022** | **2023** | **2024** | **2025** | **2026** | **Assumptions** |
| Curstormer number | 10 | 120 | 1440 | 17280 | 207360 | **1200% customer growth rate/annum** |
| Device and setup cost | £ (255.00) | £ (280.50) | £ (308.55) | £ (339.41) | £ (373.35) | **Increase in line with inflation** |
| Device Sale | £ 300.00 | £ 330.00 | £ 363.00 | £ 399.30 | £ 439.23 | **15% margin on sale** |
| Device Margin | £ 45.00 | £ 49.50 | £ 54.45 | £ 59.90 | £ 65.88 | |
| Bandwidth cost | £ (42.75) | £ (43.70) | £ (44.65) | £ (45.60) | £ (46.55) | |
| Subscription fee | £ 45.00 | £ 46.00 | £ 47.00 | £ 48.00 | £ 49.00 | |
| Service margin/month | £ 2.25 | £ 2.30 | £ 2.35 | £ 2.40 | £ 2.45 | |
| Service margin/year | £ 27.00 | £ 27.60 | £ 28.20 | £ 28.80 | £ 29.40 | |
| TOTAL REVENUE | £ 720.00 | £ 9,252.00 | £ 119,016.00 | £ 1,532,649.60 | £ 19,758,193.92 | |
| Operating cost | £ (175,000.00) | £ (245,000.00) | £ (343,000.00) | £ (480,200.00) | £ (672,280.00) | **Early years supplemented by grant and investors** |
| NET REVENUE | £ (174,280.00) | £ (235,748.00) | £ (223,984.00) | £ 1,052,449.60 | £ 19,085,913.92 | |

A major challenge for our goal of broadband penetration is the non-available of funding opportunities for broadband alternative solutions deployment outside the Gigabit broadband voucher program by the UK government.

To fully develop Orb, we need to assemble a design/development team with a great design/product lead. We have done a proof-of-concept study with Sheffield University as part of a master's research project. Full report available here.

Our goal is to proceed with a Knowledge Transfer Partnership with Sheffield University over the course of 18 months to design the hardware specification and optimise the solution for a pilot in rural UK. In terms of the hardware, combining the individual components into a portable inexpensive device is also a great challenge.

## Team

Emmanuel Igbinovia – Co-founder

Grant Budge – Co founder and chair.

Timothy O Farrell – Advisor