The total cost of ownership (TCO) for fixed OnGo in the 3.5 GHz CBRS band

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1. Why CBRS matters

The Citizens Broadband Radio Service (CBRS) opens up new ways to use spectrum in the 3.5 GHz band in the US by introducing a new regulatory framework for spectrum sharing. Spectrum sharing will improve the utilization of this band and unlock valuable spectrum for fixed and mobile users. Currently, the use of this band is limited because it is restricted to legacy users (military, satellite earth stations, and wireless internet service providers or WISPs). With CBRS, the Federal Communications Commission (FCC) expands the use of the 3.5 GHz band to other users, including broadband operators, service providers, enterprises, venue managers, municipalities and public agencies. They will be able to operate over a CBRS licensed channel with a Priority Access License (PAL), or as a lightly-licensed user, under the General Authorized Access (GAA) provision. OnGo uses the CBRS band (3GPP 48 band) both for mobile and fixed access. As a result, in some locations, fixed and mobile users may contend for the same spectrum resources.

CBRS spectrum will be shared among users and made available on a dynamic basis, based on priority tiers. Legacy users retain the right to use the spectrum whenever they need it. PAL holders collectively retain access to as much as 70 MHz of spectrum in a license area, with up to 40 MHz of spectrum per PAL holder. They must protect legacy users from harmful interference, but they receive protection from interference by GAA users. GAA users collectively have access to spectrum not being used by legacy users and PAL holders in a given area, which is as much as 150 MHz of bandwidth. GAA users do not receive interference protection from legacy users or PAL holders. Spectrum Access Systems (SASs) have been created to dynamically monitor and authorize use of specific spectrum resources for PAL and GAA users based on this priority order, using geolocation databases and policy management servers.

OnGo enables multiple users to share the CBRS spectrum, and while doing so, each has use of its assigned channel based on the priority of the tier the user is in. The SASs authorize users to use the spectrum and ensure that sharing among

OnGo and CBRS

On May 08, 2018 the CBRS Alliance launched the OnGo™ brand. OnGo provides wireless connectivity with LTE using spectrum sharing in the 3.5 GHz band also known as CBRS band in USA.

3.5 GHz beyond OnGo

The 3.5 GHz band (3GPP 48 band) is available in many countries as band 42/43 TDD LTE, and it is emerging as a key 5G licensed band. Although the regulatory framework is different (shared spectrum in the US; licensed band elsewhere), OnGo users will benefit from the economies of scale of a global ecosystem that will provide the market with more 3.5 GHz infrastructure equipment and devices at competitive prices. Vendors, however, will have to adapt their products to meet the specific OnGo requirements and receive certification in the US, but we expect that most vendors will do so, especially in light of the support for OnGo by US mobile operators.

OnGo: LTE or 5G?

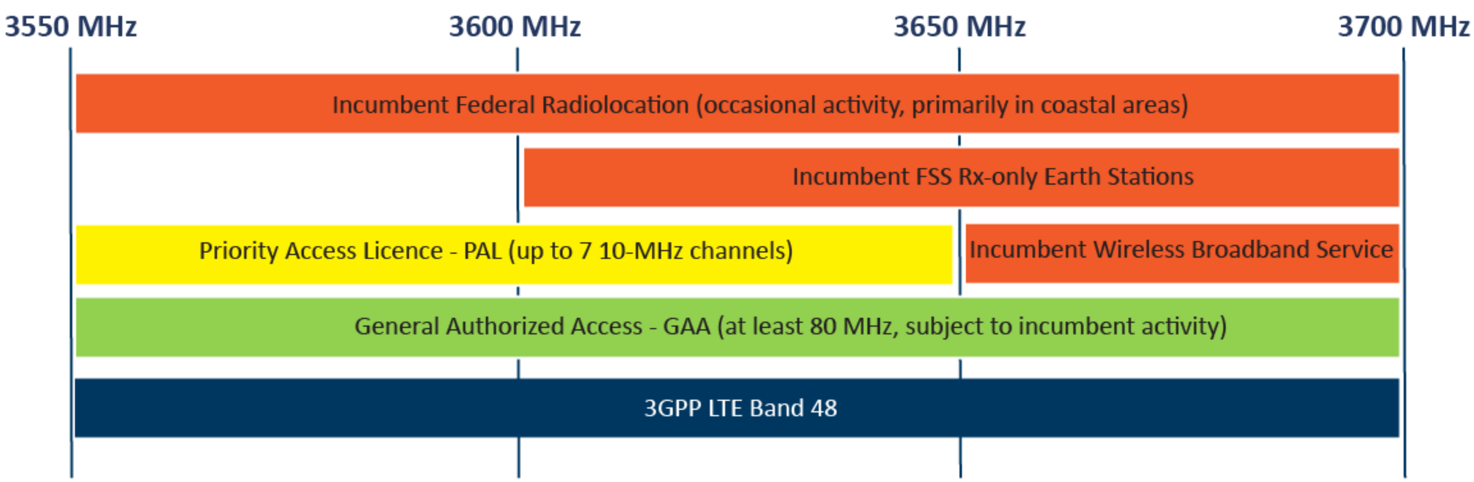
In the US, the CBRS allocation is technology neutral, but most initial deployments will use LTE. When 5G is ready for deployments, OnGo users will be able to upgrade to 5G or expand their networks with 5G.

users is fair. This use of spectrum is unlike that in unlicensed technologies such as Wi-Fi, LAA or MulteFire, where multiple users share the spectrum opportunistically, using listen-before-talk (LBT) mechanisms to determine who should transmit at any given time, without the intervention of an external entity such as the SAS.

This framework for spectrum assignment creates a unique value proposition for OnGo users: it allows easy, although unprotected, GAA access similar to Wi-Fi in unlicensed bands, combined with the ability to obtain higher-tier protected operation as a PAL holder if desired.

For additional background information on CBRS and OnGo, please download our report "Learning to share. CBRS in the 3.5 GHz band changes how we use spectrum."

CBRS spectrum



Source: Google

Legacy users (labeled in red) include the military (3550-3700 MHz; costal locations use 3650-3700 MHz, and terrestrial 3650-3700 MHz), satellite providers (3600-3700 MHz) and WISPs (3650-3700 MHz) have top access priority.

PAL access (yellow) is limited to licensed users in the 3550-3650 MHz portion of the 3.5 GHz band.
All other users registered with a SAS can use the spectrum when the SAS determines that spectrum use will not interfere with higher priorities, in channels throughout the overall band (3550-3700 MHz) under GAA (green).
The CBRS band corresponds to 3GPP Band 48.

2. The OnGo framework for fixed wireless

There are multiple use cases for OnGo. Some are for mobile access. OnGo can provide additional capacity – in congested areas by using small cells that do not interfere with the macro layer, or in private networks in enterprises and public venues, for access or Internet of Things (IoT). Other use cases are for fixed access and include backhaul, point-to-point and point-to-multipoint links, some IoT applications, broadband connectivity to residential and business users, and public and private safety networks. Fixed and mobile use cases can be combined within the same network: an enterprise may use OnGo for fixed industrial IoT applications, and for employee access through mobile devices.

In this paper, we limit our attention to use cases that use OnGo only for fixed wireless applications – and specifically the WISP, public venue, and enterprise use cases. Fixed-wireless use cases are important to OnGo's success, because OnGo provides spectrum at a frequency well-suited to limited-range, non-line-of-sight, point-to-multipoint wireless networks, which can be used for broadband access, backhaul or IoT connectivity.

Fixed wireless broadband services are likely to be the first deployed, because they do not depend on the lengthy adoption timeline that is typical for consumer mobile devices. Mobile use is driven by the consumer electronics market since handset vendors have to begin supporting the new band and subscribers have to buy the handsets. In fixed topologies, the network operator controls both ends of the radio link, and equipment vendors can provide access devices (e.g., UEs, CPEs, or IoT devices) specifically developed for an application or use case that does not require mobility support and hence does not have the same interoperability requirements that mobile devices have to meet. The opportunity to deploy OnGo networks without having to wait for wide adoption of mobile consumer devices will accelerate initial deployments.

The framework for fixed OnGo is different from current fixed wireless links in at least four key respects:

- OnGo users may choose the protection afforded by PALs, the simpler licensing arrangement afforded by GAA, or a combination of both.
- OnGo empowers users who control the venue's real estate, because they decide whether to install their own private networks or partner with operators, service providers, neutral hosts, or other parties.
- OnGo fixed users that share the ecosystem with mobile networks become less dependent (if they so choose) on proprietary solutions. Standardized products will be available at high economies of scale, bringing the total cost of ownership (TCO) down as well.
- Deployments may combine fixed and mobile services using a common infrastructure. This may earn fixed operators additional revenues from wholesale agreements with mobile operators or other service providers that may want to give their subscribers access to the OnGo network on a roaming basis.

3. A TCO model to assess the business case for fixed OnGo applications

A common question about fixed OnGo is how the business case stacks up against other fixed wireless bands and technologies. There is no single answer, for two reasons.

The first is that there are many fixed wireless solutions, each with a different value proposition. Some use cellular spectrum, some use 5 GHz unlicensed spectrum, others use microwave or millimeter-wave bands. Price, reliability and performance vary substantially among them, and the choice of which technology to use for fixed connectivity depends on availability and requirements, as well as on cost. Furthermore, within each band, equipment costs vary substantially among vendors. In sum, there is no average TCO for a point-to-multipoint deployment, and it is not possible to make an encompassing, direct comparison to OnGo.

The business case comparison is also difficult because some cost assumptions for OnGo deployments are still tentative, and because the regulatory framework is new and not yet finalized at the time of writing. We do not know how much prospective users are willing to pay for the licenses because we still do not know how the licenses will be issued. To a large extent, the regulatory details for PAL will determine the value of the licenses, but they will also influence prospective OnGo users' decision when choosing between PAL and GAA for their OnGo access. After PAL auctions we will be able to assess the impact of licensing with greater accuracy.

To address these issues, we based our TCO model on extensive interviews and feedback from CBRS Alliance members, other ecosystem players, and potential OnGo users. Among the latter, we discussed the OnGo opportunity with WISPs that currently use the 3.5 GHz spectrum for access (and they will continue to do so as legacy users until 2020–2023, at which point they must transition to CBRS), and so they are in a privileged position to compare OnGo with the proprietary fixed wireless technologies they currently use.

The TCO for OnGo and 3.5 GHz fixed wireless: a comparison
Equipment costs will be comparable, especially on the high-end solutions. Lower-cost solutions will initially be less common for OnGo, as is typical for any new technology. But in the long run, we expect a wider choice among vendors in terms of price, performance and reliability, due to the wider ecosystem for LTE and 5G compared to proprietary equipment. More specifically, OnGo will benefit from the global economies of scale from the TDD LTE bands 42 and 43, which overlap the CBRS-specific band 48.
Planning, installation and operating costs are also similar to other fixed wireless technologies, assuming that the entity deploying the network is the same and that the equipment form factor is comparable.
WISPs operating in the 3.5 GHz 3GPP 48 band will initially be able to use the band without paying licensing fees, either using GAA access with OnGo, or as incumbent users. However, WISPs will also have the opportunity to get a PAL and this will introduce a cost. However, the license costs for PAL is expected to be lower than those for exclusively licensed spectrum due to the tiered priority structure in the band.
SAS fees add a cost item to OnGo. In return, the SAS may add value to users by managing and mitigating interference.
OnGo networks need to support basic LTE core functionality, but the costs are comparable to those for network management for other fixed wireless technologies.
With OnGo, WISP legacy users get access to more spectrum, and this translates into a lower per-bit cost. It also lets WISP legacy users serve a greater number of subscribers or support higher data rates for the current number of subscribers.

As a result, we present here a five-year TCO model for OnGo for three different use cases (WISP, hospital and enterprise) and compare the results among these scenarios (see table below). In the WISP case, there are several differences between the TCO for 3.5 GHz fixed wireless and the TCO for OnGo (see table above), although the impact of these differences varies across WISPs operating in different environments and using different business models.

TCO model assumptions
The TCO model is based on one OnGo base station, for ease of comparison across use cases. The network-wide TCO can be derived by expanding the single-cell TCO to the desired number of base stations.
Each base station serves a set number of subscribers (WISPs), broadband links (hospital and enterprise), and IoT connections (enterprise).
The OnGo base station is an incremental addition to an existing network, so the costs of setting up a greenfield network are not included. We do not include potential savings from sharing the infrastructure with other fixed wireless technologies. For instance, a WISP that currently uses a 5 GHz solution could add OnGo to the cell site and share backhaul, saving on lease and operational costs by co-locating the equipment. This is a cost-effective approach to expanding capacity in growth areas. It also reduces the per-bit cost for both the 5 GHz and OnGo solutions.
There is no historical data on OnGo equipment, but we obtained reliable estimates of projected costs from talking to WISPs and CBRS Alliance vendors, and we benchmarked them against other fixed wireless solutions.
SAS fees have not yet been established, although OnGo ecosystem players agree that they will have to be kept at reasonable levels – i.e., levels that do not destroy an otherwise good business model – for OnGo to succeed in fixed applications. Our estimates combine inputs from OnGo players and WISPs, as well our analysis of acceptable levels of SAS fees in the context of the TCO model. SAS fees include a setup fee (capex) and a recurrent fee (opex) for the OnGo base station and for the fixed CPEs. We conservatively assume that CPEs exceed mobile device power limits and hence the WISP has to pay SAS registration fees. There is no SAS registration requirement if the CPE power is below the mobile device threshold.
LTE-based networks, including those used in OnGo, require an Evolved Packet Core (EPC). We assumed that the base station includes a stripped-down EPC that supports the functionality required for fixed connectivity but excludes mobility.
Estimates for the cost of PALs are uncertain at the time of writing because the FCC has not yet set the final rules for the license auction. The license cost per cell site is variable, because it depends on the density of base stations within the area covered by a license. We expect PAL fees to be substantially lower than license fees for prime mobile spectrum, because of the spectrum-sharing restrictions. Only the WISP model includes PAL fees. The hospital and enterprise models use free access under GAA.
We assumed that the WISP, hospital and enterprise are directly responsible for the capex and opex, but other business models are possible and likely to accelerate OnGo deployments. The TCO in such cases may be split among the different participants (e.g., enterprises, neutral hosts, mobile operators).

WISP (Subscriber model)	Hospital (Venue model)	Enterprise (Venue and fixed IoT model)
One base station supports a growing number of subscribers. Subscribers pay a monthly fee to get a broadband connection to their premises. The WISP manages the network, but the CPE is in a location the WISP does not control.	Fixed links connect buildings or other locations that need high-capacity data connections. End-to-end links are managed and controlled by the hospital and are within the hospital real estate.	Fixed links connect buildings or other locations that need high-capacity data connections, and connect IoT devices such as cameras in fixed locations. End-to-end links are managed and controlled by the enterprise and within the enterprise real estate.
Subscribers generate a monthly revenue of $55	No revenues	
Higher number of subscribers (32 in Y1, to 128 in Y5)	Fewer high-capacity connections (20)	Mix of high-capacity connections between buildings and lower-capacity connections for IoT (60)
Lower capacity per link (3 Mbps, uncontended, at capacity)	Highest capacity per link (23 Mbps, uncontended, at capacity)	Medium capacity per link (8 Mbps, uncontended, at capacity)
Lowest per-link cost	Highest per-link cost	Medium per-link cost
One three-sector base station		
Low-cost CPE ($160 in Y1 to $100 in Y5)	Higher-cost CPE ($500)	Mix of high-cost and low-cost CPE ($250)
Higher installation costs	Lower installation costs, due to control over location	
PAL access, with cost associated with license	GAA access (no licensing cost)	
Site lease	No site lease (real estate controlled by hospital, enterprise)	
Recurring backhaul costs (wireless microwave)	No backhaul needed, or using unlicensed spectrum or venue-owned fiber	
Customer support required	No customer support needed	
Same SAS fees		
Higher opex	Lower opex, due to control over location	
Higher TCO, due to higher number of links and higher installation and backhaul costs	Lowest TCO, due to lower number of links and lower installation and backhaul cost	Slightly higher TCO than for the hospital case, because of higher number of connections

4. The WISP use case

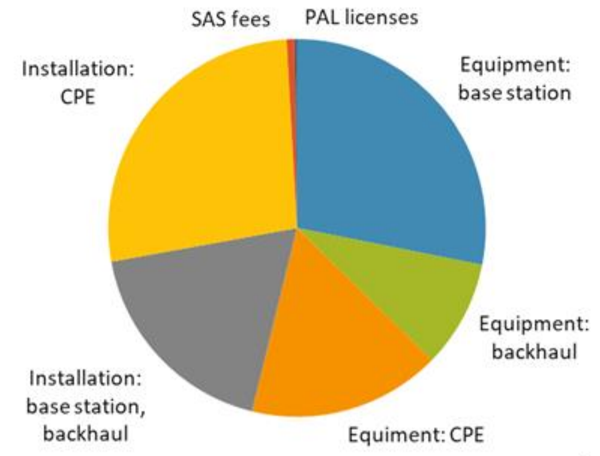
WISPs are a primary use case for fixed OnGo because they already use a portion of the 3.5 GHz band under the rules of the Wireless Broadband Service to be grandfathered as OnGo use gathers steam. WISP users will have to migrate to CBRS to retain access to the spectrum. Currently, WISPs are restricted by 47 CFR Part 90 Subpart Z to the 3.65 GHz to 3.7 GHz spectrum. CBRS opens up access to three times as much spectrum (3.55 GHz to 3.7 GHz), as PAL licensees and/or GAA users. OnGo offers WISPs the opportunity to expand coverage and capacity, enter new markets, and provide higher-capacity service, using standards-based technologies that give them a wider choice among vendors. However, there is a cost associated with the transition, and many WISPs wonder whether the gains justify it.

Our TCO model looks at the financial implications of adding OnGo base stations to an existing WISP network in an area where the WISP wants to add capacity or subscribers, or where it wants to expand its footprint. The TCO model shows the capex and opex contributions (see graphs on the right) over five years, with the infrastructure deployed in the first year and subscribers added gradually, reaching 80% of capacity in the fifth year.

We assumed that the WISP acquires a PAL and that the license will be moderately priced ($200 per base station on average) because it will cover a medium-density area. We also assumed that the WISP will use it to deploy a relatively dense network of OnGo base stations. PAL costs will vary substantially across locations, depending on factors such as demographics and competition, as is customary in spectrum licensing, and this will add variability to the TCO in actual deployments.

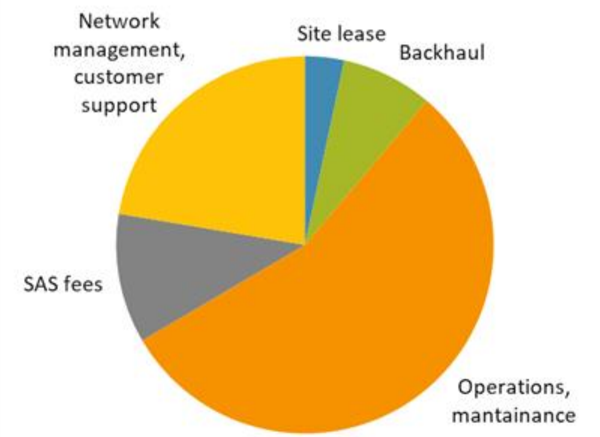
To look at profitability, we computed the incremental revenues that can be attributed to the new OnGo infrastructure, assuming the new subscribers pay the same monthly subscription fees as the existing subscribers and get comparable service – $55/month for a 30 Mbps advertised rate, with a

WISP: Capex



Source: Senza Fili

WISP: Opex



Source: Senza Fili

contention of 10 (i.e., assuming the capacity is shared by 10 users; a dedicated link has a contention of 1). This is a conservative scenario, and some WISPs may introduce more expensive plans with higher service levels. That would increase revenues and profitability over what we show here.

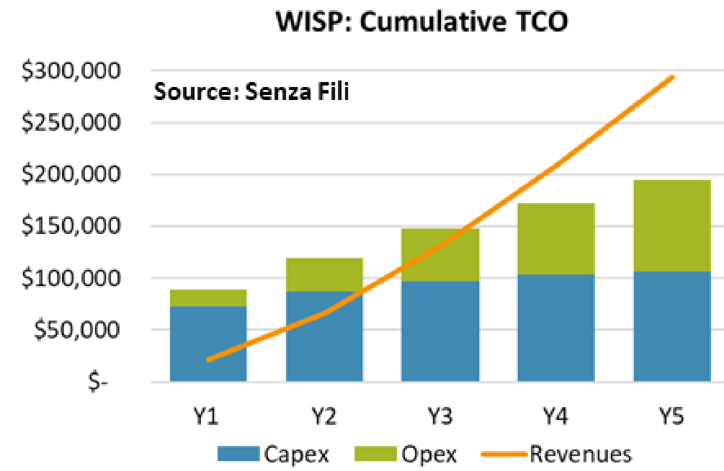
The cumulative TCO is shown, on the right, to reach almost $200,000 in year 5. Revenues reach almost $300,000 by year 5, with capex breakeven in 20 months. The base station and CPE costs per subscriber are $375. Profitability is 51% in year 5. OnGo-specific costs represent 7.7% of the cumulative costs (both capex and opex). To cover the OnGo-specific costs, the WISP needs to add 4.1 subscribers, a 3.2% increase in subscribership for this base station.

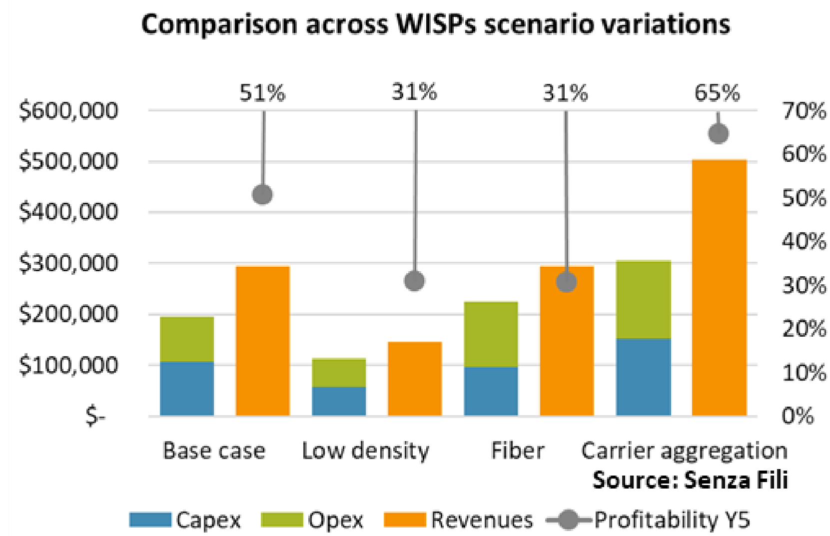
Because there is high variability among WISPs, we looked at some scenario variations to understand the sensitivity of the TCO results.

The base-case TCO rests on the use of wireless backhaul, which is capex intensive but frequently cheaper than fiber. As a result, the model has an approximately 50-50 split between capex and opex. If the WISP instead uses fiber for backhaul – where available and cost effective – the opex contribution increases, because of the fiber lease costs (we assume that the WISP does not own the fiber). Profitability decreases to 31% because of that cost increase, but revenues remain the same (the number of subscribers served is the same).

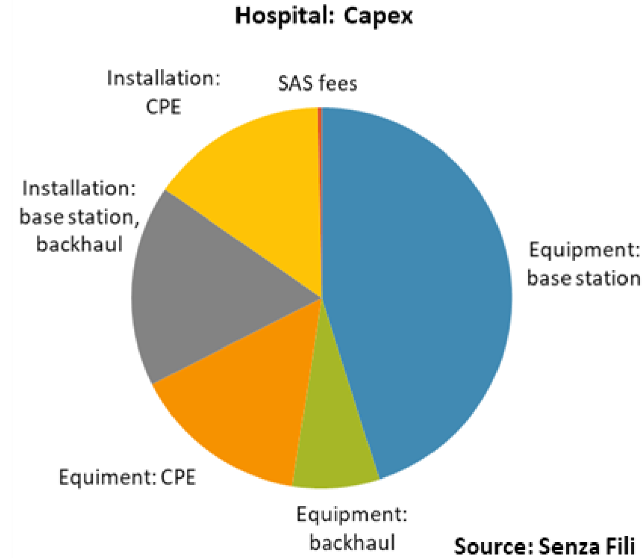
We also looked at a low-density scenario – e.g., in a rural environment – where the WISP deploys a lower-capacity base station and serves fewer subscribers, with the same plan fees but a lower advertised rate. The result is a lower TCO and lower revenues, coupled with lower profitability (31%) than in the base case, due to the higher cost of providing service.

Finally, we looked at the impact of carrier aggregation, which doubles capacity by using 40 MHz of spectrum. The TCO increases by approximately one third, but revenues grow if WISPs can serve more subscribers, and their profitability rises to 65%. The TCO analysis shows that the WISP can extract substantial benefits if it uses the additional spectrum made available through the CBRS framework.



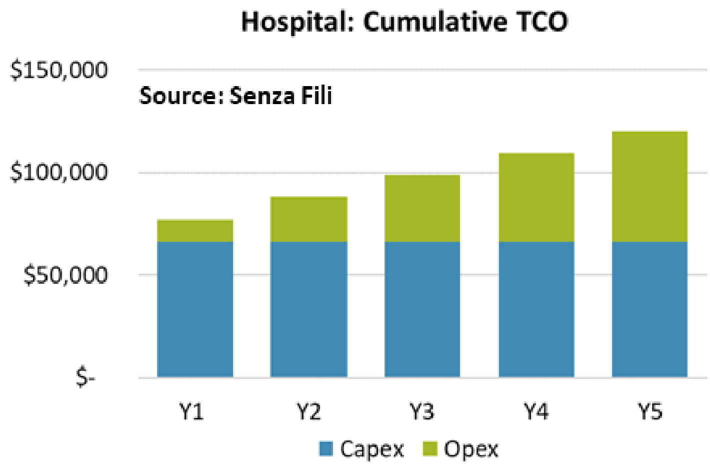


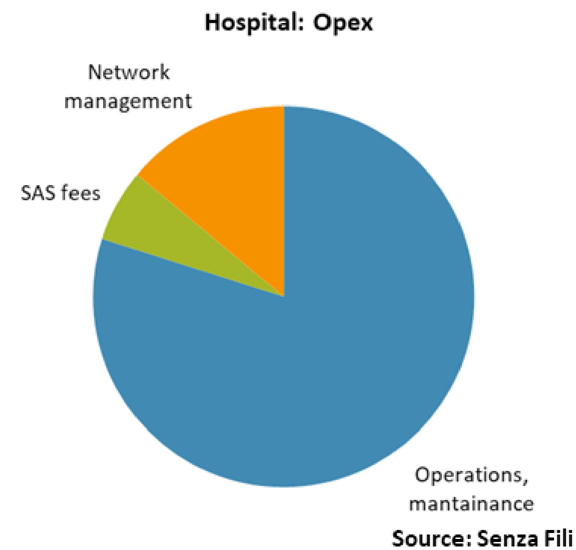
5. The venue use case for a hospital



In the hospital use case, multiple fixed links connect buildings. The number of connections is lower and the capacity is higher than in the WISP use case. Because all the traffic is internal to the hospital and managed by the hospital or by a third party on its behalf, this is a simpler deployment than the WISP one. The OnGo infrastructure serves internal users and generates no direct revenues from user access. We assumed GAA access because we assumed that the hospital – like other entities that use OnGo within their premises – has control over the real estate (and decides who can put OnGo infrastructure there), and does not need a PAL. Furthermore, it would be wasteful to purchase a license that covers a much larger area than covered by the network.

The TCO for the hospital use case is $120,000, 38% cheaper than that for the WISP. Because the hospital controls the venue where it operates, deployment costs are lower, and there are no lease costs for the base station. Also, backhaul to the aggregation point is cheaper, there is no customer support, and there are fewer CPEs to install. OnGo-specific costs, at 5.5% of the TCO, are also lower than for the WISP use case. The per-link capex is $3326 (equipment capex is $2000), and the opex is $538 per year.

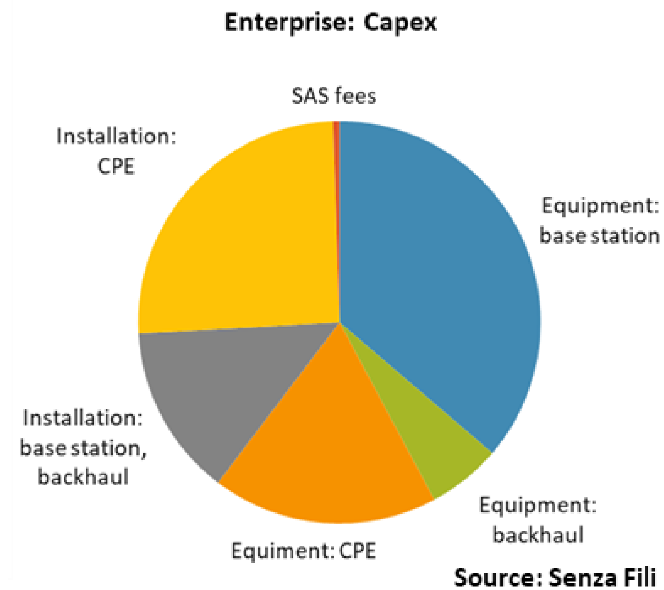


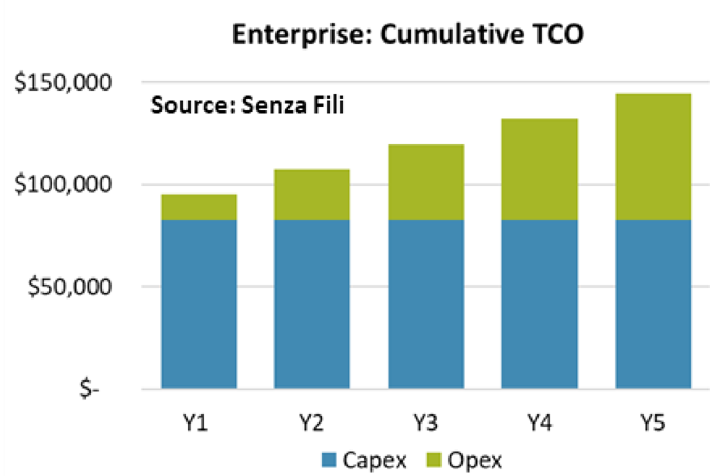


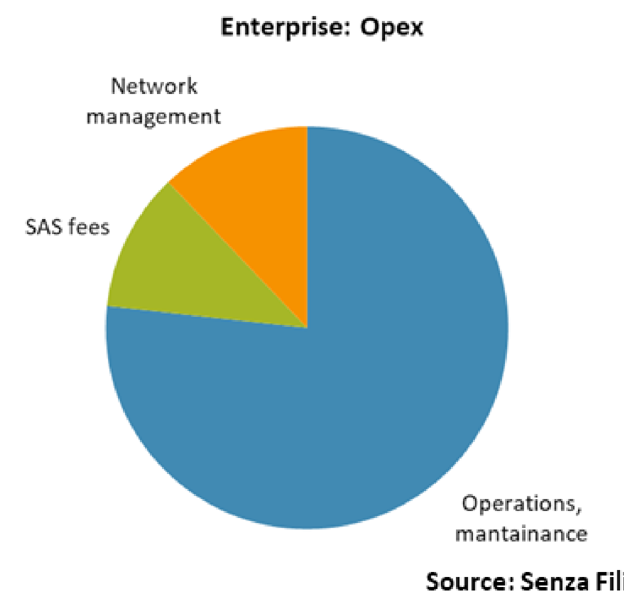
6. The enterprise use case for a manufacturing plant and office campus

In the enterprise use case, we introduce a scenario in which a company needs high-capacity fixed links to connect buildings or other assets, and to connect fixed devices used for IoT applications, such as video surveillance, monitoring, or remote-control applications. This type of network may be used in a manufacturing plant or an office campus. As in the hospital case, there are no revenues, and control over the premises translates into cost savings and no need for a PAL. Compared to the hospital case, the number of links is higher (60, compared to 20 in the hospital case), but the per-link capacity lower (8 Mbps, compared to 23 Mbps in the hospital case).

The cumulative TCO over five years is $145,000, an increase of 20% over the hospital, due to the higher number of links. OnGo-specific costs account for 7% of the TCO. The model assumes the deployment of a 4x4 MIMO base station in a 20 MHz channel. In both this and the hospital use cases, the per-bit cost can be lowered when using carrier aggregation or 256 QAM, because they would allow the support of a larger number of fixed links. The per-link capex is 1379 (equipment capex is $750), and the opex is $206 per year.







7. Implications for the business case for fixed OnGo

OnGo unlocks new, valuable spectrum for fixed and mobile users for licensed and lightly licensed access using a three-tiered system, while preserving the incumbents' rights to the spectrum assets. This innovative approach allows spectrum sharing among multiple users, which will result in a more efficient use of spectrum resources and give many wireless players the opportunity to expand their networks or deploy new ones.

Our TCO model looks at the business case for fixed OnGo for three use cases: a WISP, a hospital, and an enterprise site. Each use case has distinct requirements, so the TCO can be easily extended to assess other use cases whose requirements are similar to one of the three. Other use cases include backhaul for small cells in dense deployments, where OnGo can be used both for access and in-band backhaul. OnGo can also be used as a valuable complement for the mission-critical wireless infrastructure for public safety, where it can add coverage and capacity to the existing infrastructure. Enterprises and service providers can use OnGo for other fixed applications, and some will mix mobile and fixed access.

The business case is attractive: OnGo offers the performance of licensed spectrum to players that cannot afford to pay for a cellular license, at a lower expected cost with PAL access and without any licensing cost for GAA. In our model, WISPs can expect to become profitable by Year 3 and have a 51% profitability by Year 5. The TCO for WISPs is comparable to the one for the current legacy use with the Wireless Incumbent Access (3.65-3.7 GHz), but OnGo gives them access up to 150 MHz of new spectrum in the highly valuable 3.5 GHz band. With PAL, WISPs can get protected spectrum access to part of the 3.5 GHz band. The TCO for enterprise and other entities such a hospitals, public entities, educational institutions, and real-estate owners is also a good one. The costs are in line with those for unlicensed links, but these new users of the CBRS band get access to up to 150 MHz of spectrum that is currently not available to them and to rely on the global and standards-based LTE technology and ecosystem.

About CBRS Alliance

The CBRS Alliance believes that OnGo LTE-based solutions in the CBRS band (3GPP band 48), utilizing shared spectrum, can enable both in-building and outdoor coverage and capacity expansion at massive scale. In order to maximize CBRS' full potential, the CBRS Alliance aims to enable a robust ecosystem towards making LTE-based OnGo solutions available. The mission of the CBRS Alliance is to evangelize LTE-based OnGo technology, use cases and business opportunities while simultaneously driving technology developments necessary to fulfill the mission, including multi-operator LTE capabilities. The Alliance has also established an effective product certification program for OnGo LTE equipment in the US 3.5 GHz band ensuring multi-vendor interoperability. For more information, please visit http://www.cbrsalliance.org and follow CBRS Alliance on LinkedIn and Twitter.

About Senza Fili

Senza Fili provides advisory support on wireless technologies and services. At Senza Fili we have in-depth expertise in financial modeling, market forecasts and research, strategy, business plan support, and due diligence. Our client base is international and spans the entire value chain: clients include wireline, fixed wireless, and mobile operators, enterprises and other vertical players, vendors, system integrators, investors, regulators, and industry associations. We provide a bridge between technologies and services, helping our clients assess established and emerging technologies, use these technologies to support new or existing services, and build solid, profitable business models. Independent advice, a strong quantitative orientation, and an international perspective are the hallmarks of our work. For additional information, visit www.senzafiliconsulting.com, or contact us at info@senzafiliconsulting.com.

About Monica Paolini

Monica Paolini, PhD, founded Senza Fili in 2003. She is an expert in wireless technologies, and has helped clients worldwide to understand technology and customer requirements, evaluate business plan opportunities, market their services and products, and estimate the market size and revenue opportunity of new and established wireless technologies. She frequently gives presentations at conferences, and she has written many reports and articles on wireless technologies and services. She has a PhD in cognitive science from the University of California, San Diego (US), an MBA from the University of Oxford (UK), and a BA/MA in philosophy from the University of Bologna (Italy). You can contact Monica at monica.paolini@senzafiliconsulting.com.