2020

Building and Connecting the FSM FTTH Network

INFORMATION FOR POTENTIAL CONTRACTORS TO OAE

OCTOBER 2020

1. Overview

The purpose of this document is to provide a high-level overview of the new Fiber to the Home Network that OAE is going to rollout on behalf of the FSM National Government. A key goal of the National ICT and Telecommunications Policy is to ensure that as many homes, businesses and offices of the FSM have access to world class connectivity at an affordable and equitable price.

The information is a high-level view of OAE's assumptions at the time of writing and are subject to change and improvement. They are for information purposes only. The actual bidding documents, Terms of References and contracts will have further detail when they are developed.

Throughout this document the term Open Access Entity (OAE) is used to refer to the FSM Government owned organization that owns and operates the wholesale network. The OAE's legal name is FSM Telecommunications Cable Corporation (FSMTCC) and as this is similar to the legal name of Telecom (FSMTC) to avoid any confusion OAE is used to mean the wholesale only business building the new FTTH network and Telecom is used to refer to the retail telecommunications company Telecom.

The initial scope of the program to the main islands of Yap, Pohnpei and Kosrae. The inner lagoon of Chuuk state is in the wider scope but is slightly more complicated due to FTTH already being deployed in Weno and the need to coordinate FTTH build in the other islands of the lagoon with power infrastructure upgrades. Once the high-level strategy and plan is confirmed for Chuuk, the build is expected to follow the same process as for the other states.

For more information or to understand further the plans and processes, please get in touch with:

Mr. Peter Garamfel

National Rollout Manager

pgaramfel@fsmcable.com

2. Introduction to the FSM Telecommunications Industry and Regulatory Environment

2.1. Introduction

OAE is a participant in FSM telecommunications industry. Broadly, the telecommunications industry can be defined as fixed and mobile calling, messaging, data and internet service. These products are delivered across a variety of platforms.

The diagram over the page illustrates the high-level structure of FSM's fixed access and mobile networks infrastructure, and how telecommunications networks typically transfer information from a local premise (e.g. an internet browser or email in a home) via exchanges and potentially international undersea cables to its intended destination. The telecommunications network shown below broadly includes the network infrastructure and equipment to deliver communications services both within FSM and to the outside world, allowing fixed and mobile phones and data devices such as computers to communicate with other devices.

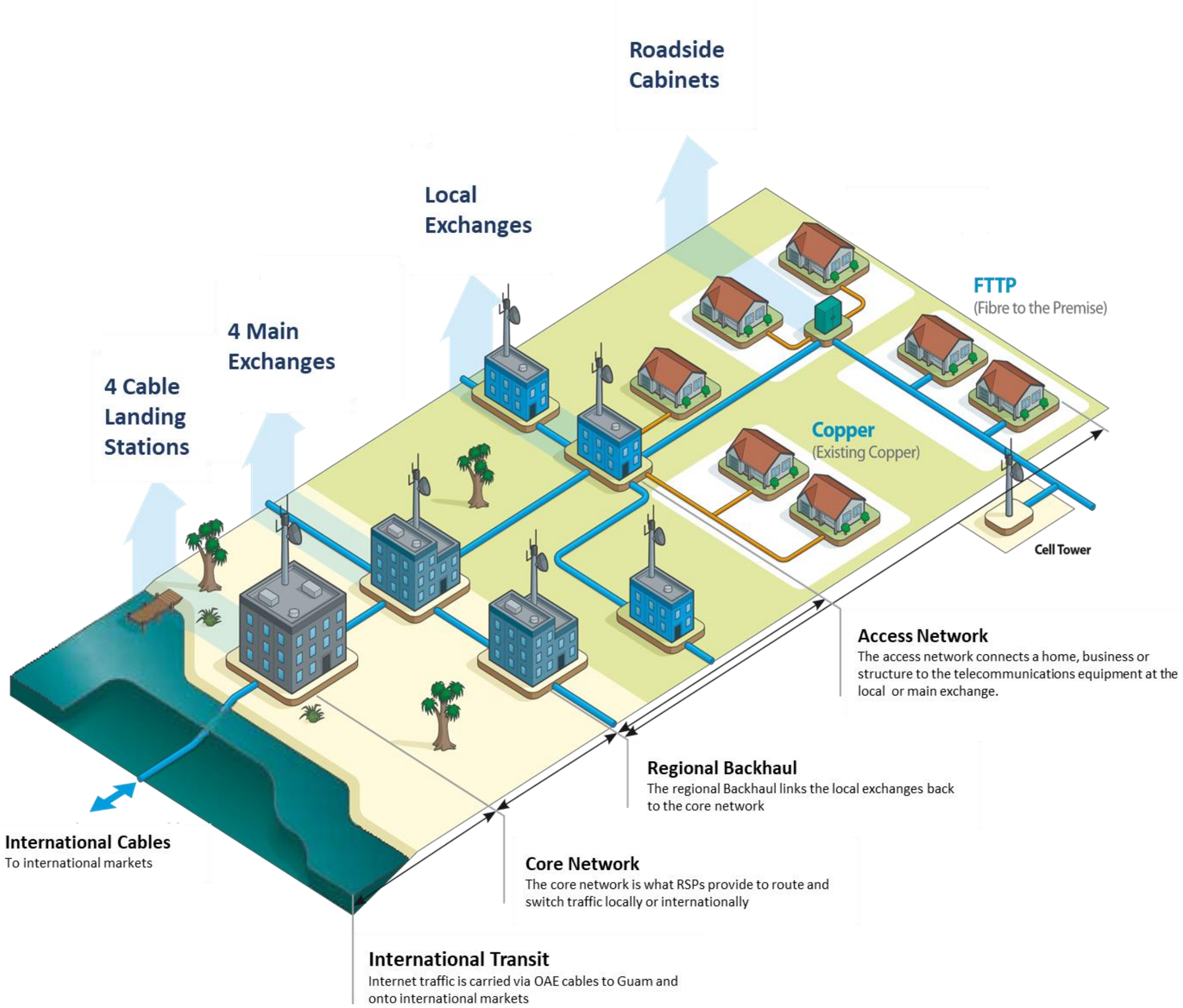


Figure 1 - Different components of the FSM telecommunications networks

FSM Network Overview

The original FSM telecommunications network was based on copper cables that carried the voice and data traffic and, whilst fiber has been added in limited means as a backhaul technology, use of copper is still predominant. It is what is used to provide nearly all fixed telephony and internet services throughout FSM.

In more recent times, telecommunication networks have begun to transition towards the use of fiber optic cables (fiber) throughout the core network, regional backhaul and the access network. This technology allows data and information to be sent down a very thin strand of glass via light waves rather than electrical signals. Light transmission allows for higher data rates than conventional copper wire, coaxial cable and many forms of radio transmission and as a result more information can be transferred quicker from one point in the network to another when compared to the older network technologies.

The diagram above illustrates in more detail the range of connection options from a home, business or other location to the first traffic aggregation point in the network (often an exchange or cabinet). Underlying access technologies that enable access to the network include copper, fiber and other cable networks as well as mobile and fixed wireless services.

Existing network architecture

Across the fixed local access network there are three main methods of connection of a premise to the local exchange (1) Directly connected to the exchange through copper (2) Connecting to a cabinet by copper and then from the cabinet to the exchange on fiber or, in the future, (3) Directly connected via fiber. Within FSM the objective of the Government's Digital FSM Initiative is to deploy a fiber to the premise (FTTP or FTTH) local access network infrastructure throughout the main islands of each state.

The copper access network (often referred to as the local loop) is currently the most common form of local fixed access network connection in FSM and utilises copper for the connection between a premise and a roadside cabinet or local exchange.

The Government's Digital FSM Initiative will see the construction of a fiber to the premise (FTTP) network. This network will utilise fiber cables from the exchange to roadside cabinets as well as over the final connection between the roadside cabinets and the end user premise. Typically the FTTP local access network architecture allows for the highest data speeds and capacity which enable high bandwidth end user services such as Internet Protocol Television (IPTV) (whereby television is delivered via the internet or another access network) and high definition video conferencing, which are less effectively delivered over existing copper access networks.

2.2. Key telecommunications definitions

The Open Systems interconnection model

The Open Systems Interconnection model (OSI model) can be used as a further way of describing a telecommunications system and is based on layers which subdivide the system from the physical assets in the ground right through to the application on a computer being used by an end user. The model is composed of seven individual layers and each layer builds on the next to enable the transfer of data and information between two or more points in a network.

Within the telecommunications industry the concept of OSI model layers are used as a basis on which services and products are described. They are used as useful "breaks" to describe the differences between the technologies and services that wholesale service providers like OAE deliver to retail service providers.

Layer 1

Layer 1 within the OSI model is classified as the physical layer and within a telecommunications fixed access network this can be considered to comprise copper and fiber cables and co-location space inside exchanges or cabinets. At the physical layer, data is transmitted using electric voltages through copper and pulses of infrared or ordinary light through optic fiber. In the situation where a retail service provider purchases access to physical assets, for example dark fiber access, this is referred to as a Layer 1 product within the OSI model.

It is a Layer 1 product that will be the basic service that OAE intends to provide to service providers. OAE does not intend to provide any electronic systems for local access.

Layer 2

Layer 2 within the OSI model is classified as the data link layer and provides the functional and procedural means to transfer data between network entities. Within the telecommunications fixed access network this can be considered to comprise of the equipment and services which transmits basic data from one point in the network to another over the Layer 1 physical assets.

OAE today provides layer 2 services to link between FSM states and the international connectivity to Guam. In long range submarine cables, it is neither practical nor efficient to provide long-haul dark fiber to individual service providers.

Fiber to the Home

Fiber to the Home (FTTH) is a now a mature technology that has achieved scale deployment over the last ten years. FTTH uses fiber all the way from the telephone exchange to the end user's home. It allows for practically unlimited bandwidth and has a lower cost to deploy and maintain than copper networks.

The key innovation in modern FTTH networks is that they take advantage of the long distances that fiber systems can work over without requiring and amplification or additional electronics. In a typical local access network designed for mass market, customers can be up to 20km away from the where the main telephone exchange is located and still get the exact same service as the person who lives right next door to the exchange. This is fiber's key advantage over copper or radio technologies – the distance it drives and the near unlimited bandwidth.

OAE will provide the fiber that links from each individual premise back to the telephone exchange. It will provide a jack point (Internal Termination Point ITP – in diagram below) in the home and co-location space (room to place equipment) in its exchanges. The service provider uses the fiber to connect its modem or WIFI router that it provides to the end user to its equipment in the exchange. OAE maintains and looks after the fiber between the home and the exchange.

OAE will also then provide the inter-state and international capacity to connect from the telephone exchange to the rest of FSM and the world.

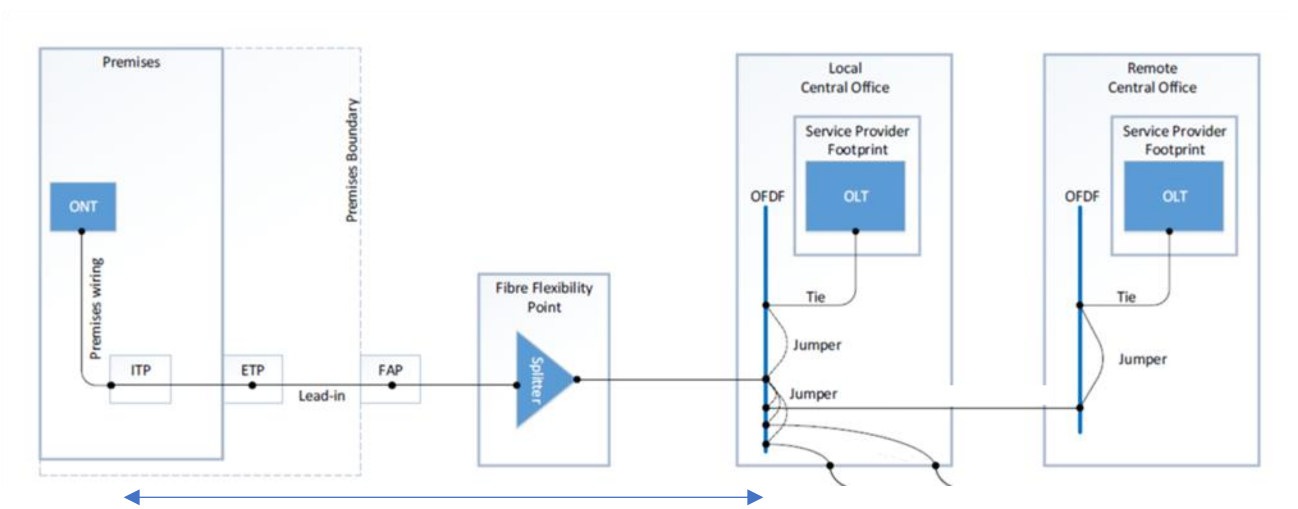


Figure 2- OAE's access business. Items between the arrows are the likely scope of OAEs business. Retail service providers will provide equipment in the home (Optical Network Terminal - ONT) and at the telephone exchange (central office) – (Optical Line Terminal -OLT)

Open Access Fiber Network

An Open Access Layer 1 Network is designed to allow for multiple providers electronic equipment to be used. Each operator or service provider gets equal access to the same underlying network no matter how large or small they are.

The network must be designed to easily allow the following services:

- Colocation space, power and cooling at the Central Office;
- Dark fiber backhaul from the splitter location to the CO;
- Splitter colocation space;
- Built so that multiple service providers can achieve a minimum viable scale; and
- Dark fiber between splitter location and home.

An open access network is built less efficiently than it would be for just one operator. The trade-offs that network regulators and policy makers make in most markets (including FSM) is that the small increase in cost is made up for from the consumer benefits from lower prices, innovation and high-quality services provided to end users.

When comparing an open access Layer 1 network to one built for only one operator; the main differences are typically that the first splitter is located much closer to the customer (typically in the pole or pit) with no space for additional splitters and minimal spare fibers back to the central office. The costs for the single operator are marginally lower, but the design prevents any other person from being able to use the network. In this environment a competitor could only use the technology and pricing that is set by the network builder.

The key point is that the deliberate choices made in how the network is designed and built makes it better or worse for allowing others to access fiber services.

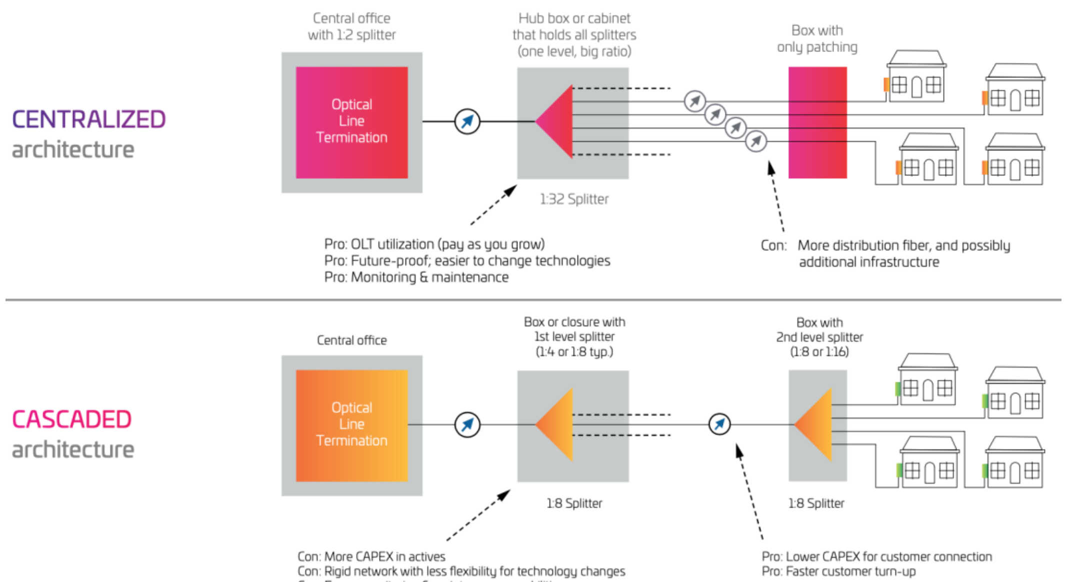


Figure 3 - Comparison of open access (at the top) network design to vertically integrated (at the bottom) network design. The difference between the two is about how economically feasible it is to have more than one operator.

2.3. FSM Regulatory Environment

After completing a comprehensive ICT Policy review in 2011, the regulatory environment in FSM has changed considerably. Previously all telecommunications services were delivered exclusively by FSM Telecom Corporation, a Government owned corporation.

The FSM Telecom Act 2014 Amendment introduced significant changes

- Opened FSM for multiple Telecommunications license holders
- Allowed for establishment of the Telecommunications Regulation Authority
- Allowed for establishment of the Open Access Entity: FSMT Cable Corporation

The Telecommunications Regulation Authority (TRA) was formally established late 2018. The TRA has internationally recognized expertise and published its rules in October 2019.

The TRA prefers commercial resolution as the primary means of resolving industry disputes. The orientation is for licensees to propose new services and investments to the industry and that the TRA only gets involved where there is a dispute. It does not approve or set services, that is for the industry to agree between itself. However, it has all the necessary powers to resolve any issue and is guided by the principles in the 2014 Act.

3. Business Overview

OAE will become FSM's largest telecommunications utility business and will be the nationwide owner and operator of the new fixed line access network infrastructure as well as its existing international cable links. Assets will comprise of local exchanges[1] in each State and will grow to approximately 7,000[2] lines connecting FSM homes and businesses. A range of telecommunications providers will use OAE's network to deliver phone and internet services to FSM citizens and rely on OAE's fiber network capability and expertise to build and maintain their communications services. The deployment of fiber is central to the Government's Digital FSM Initiative in respect of which OAE has a leading role.

OAE will:

- Continue to provide international and interstate submarine cable transport, expanding to all states in FSM with the completion of the Kosrae cable systems.
- Be a national provider of Layer 1 wholesale local access fiber services to retail service providers.
- Provide a comprehensive range of backhaul and co-location services to retail service providers.
- Sell open access, non-discriminatory and equivalence of inputs services (i.e. with exactly the same price and technical specification) to its customers.
- Manage its fiber network through provision of build, installation and maintenance services.

[1] OAE will operate facilities that will be like a telephone exchange. It will be the physical location where fiber is terminated and OAE will offer space for service providers to connect their equipment to OAE fiber. Telecom will continue to own its existing copper-based telephone exchange buildings.

[2] Excluding Chuuk Lagoon. Exact number addressed by OAE will depend on how Chuuk is addressed which is not yet finalized.

- Connect end-users (consumers, businesses and Government offices) and install certain equipment in their premises.

As the network grows and reaches capacity, the fiber local access business should grow to approximately $1.5m per annum within five years, connecting over 7,000 homes, businesses and government offices.

OAE's total business will grow to approximately $3m, providing local access, inter-state and international connectivity to all of FSM.

4. Business Strategy

OAE's strategy is to drive uptake and usage of connectivity as a key component of the Government's Digital FSM policy. OAE will do this by becoming FSM's nationwide provider of telecommunications infrastructure, serving all customers on an open access basis through a fiber network and delivering innovative services to FSM customers.

In the near term, the strategic priority for OAE will be to transition to a new business model while building the new fiber network, creating momentum as the country transitions to a fiber-centric communications infrastructure.

5. OAE's customers

The OAE customer base will grow over the next five years from a single customer to multiple retail service providers. They will buy Layer 1 local access and Layer 2 international transport services on an equivalence basis.

Under the 2014 regulation in the Telecommunications Amendment Act, OAE is prohibited from providing services to retail end-users such as consumers, SMEs and corporates. The TRA will maintain a register of license holders (non end-users) to whom OAE can supply services. The TRA will assess the eligibility of new non end-users and only once a company is on the register will OAE be able to supply products and services to that company.

OAE's success will depend on having a thriving set of retail service providers who will compete to offer internet and other services over the OAE network. The development of multiple retailers will encourage innovation and service uptake.

OAE has been talking to numerous local and international providers about the potential of FSM as a market. Whilst the small market size and remote location make it challenging, there is interest.

OAE is also confident that locally based providers will be able to start and enter the market. They will be able to bring a fresh and locally FSM based approach to selling and supporting telecommunications. It is likely that the evolution of Retail Service Providers as they develop their businesses will impact and improve product, pricing and network plans. The underlying premise of OAE is that it is able to adapt to its customers changing needs.

6. The new fiber network

6.1. Overview

In May 2020, following the conclusion of detailed discussions between the National FSM Government and the World Bank, The Digital FSM Project was deemed effective by Congress and OAE has been established as the implementing agency for the national connectivity component.

This program of work will see OAE deploy fiber to homes, businesses, schools, hospitals and health service providers within the main islands of each state. The World Bank investment in connectivity is approximately $15m, including an allowance for services to the outer islands.

The deployment of the fiber network is a significant undertaking. OAE estimates that to build the network OAE will require the deployment of approximately 760 kilometers of new fiber lines alongside roads, either underground or on existing power infrastructure to build the communal network. It will also require additional deployment of fiber from the communal network to connect a premise.

The Network deployment will require the support of multiple parties and suppliers in respect of the significant civil works required to deliver against the deployment plans. OAE expects that this will require approximately 30 additional technicians, employed by OAE's third party suppliers, to achieve the plans. These additional roles are expected to be met by local FSM people.

OAE commenced the high-level architecture and design in November 2019 using Project Preparatory Advance funding from the World Bank. Further detail on the architecture and approach is available in the FSM FTTH High Level Architecture and Assumptions paper dated March 2020.

The fiber build is expected to continue through to 2025. The new fiber build will comprise two components:

1. Communal infrastructure which will deliver fiber past premises; and
2. the connection of individual premises to the communal infrastructure as dictated by demand, including installing equipment in the end-user's premises and in the exchange to enable service delivery.

Contracts for these two elements are to be procured separately.

The purpose of this paper is to provide further high-level details before the detailed contracts are available. The goal is to educate and engage the contracting community in FSM ahead of time so that faster progress can be made of delivering high speed internet access.

The build of the communal infrastructure is to establish the initial network along roads and is expected to be completed through 2021 and early 2022. The connection of individual premises will start once the first communal network is built in each state and will continue on for a longer period of time. OAE expects that the bulk of the network migration will occur during 2022 and will largely be complete by 2024.

While the contracts are to be let separately, there is no reason why one provider could not bid for building the communal network and then connecting the individual homes and offices.

OAE does note that the skills for building the communal network and connecting customers are different. The former is more akin to civil utility build like water or roading, whereas the latter is a more customer service oriented as requires technicians to go into each and every home to connect them to the new network.

High level plan

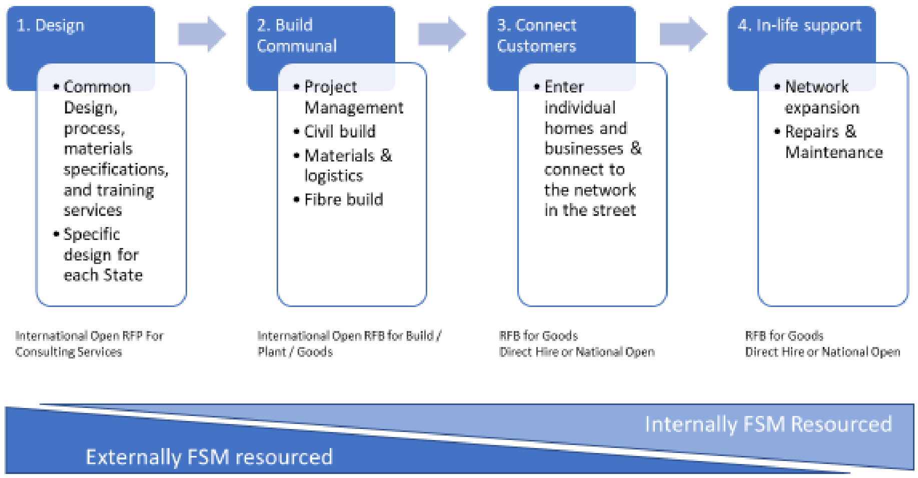


Figure 4 - Stages of transition of the new Fiber network from build to operate. Stage 1 – the Design Phase has already started. This document focuses on 2 and 3. OAE expects that the organization who undertakes stage 3 would also be a likely candidate for stage 4.

6.2. Building the communal network

The communal infrastructure deployed by OAE must at a minimum pass all premises in the main island of each state that currently receives copper telephony and ideally to all premises.

The plan is to start in Yap and then move onto Pohnpei and Kosrae. The plans are still in the process of being developed and expect to be confirmed later through 2020.

Details for Chuuk and the islands of the inner lagoon will be completed once the plans for the three other states are under way. This is expected later in 2020. Chuuk is more complicated owning to the existence of fiber to the home in Weno and the technical design complications around reaching the islands of the lagoon.

Deployment of the communal infrastructure will be achieved utilizing several deployment methods. Wherever economically viable, the network will be deployed underground using low impact micro trenching technology. However, until the deployment of the network is fully underway the exact deployment method mix will not be known and could change significantly and will vary throughout the deployment.

The communal network also includes the establishment of a fiber central office. This is where the fibers are terminated and handed over to retail service providers and it is usually located in a geographically central location so to minimize network construction costs. OAE can either establish new locations, expand within the existing footprint it has for international cable landing stations, or find an agreement with a third party to provide space.

OAE will provide a detailed design that it will then ask contractors to build. OAE's goal is to be able to broaden the range of potential contractors outside the traditional telecommunication field. The contracts may be to install new underground conduit with breakout pits and boundary connections to each premises;

or it could be affixing cable to utility poles and installing termination boxes ready for individual customer connection. OAE expects these tasks to be within the skill set of a much wider range of organizations. It is looking for civil contractors to place the materials either underground (reinstating the surface to agreed standards) or on existing utility poles.

OAE will provide the materials, detailed instructions, necessary permissions and agreements with National, State and Municipal Agencies and fiber specific training.

Depending on the capabilities of respondents, some tasks like property access permissions, and state and municipal agency agreement for build may be contracted to the network builder rather than OAE.

It's expected that some specific requirements, like the build of a central office will be separated out as they are quite specific tasks. Others, OAE expects to be able to contract on a per task basis (i.e. per meter of underground conduit installed, per underground FAT installed or per utility pole for aerial work).

6.3. Connecting customers – connection of fiber to premises

OAE will connect customer premises and install equipment in customers' homes to enable service delivery to retail service providers. Ultimately, the connection of premises will be driven by end-user demand for fiber-based products and services. End customers will need to order a service through their service provider and the service provider will need to then order a service from OAE.

Connection requests are expected to come from either new service providers winning customers from Telecom or from Telecom choosing to migrate customers from its existing network to the new fiber network.

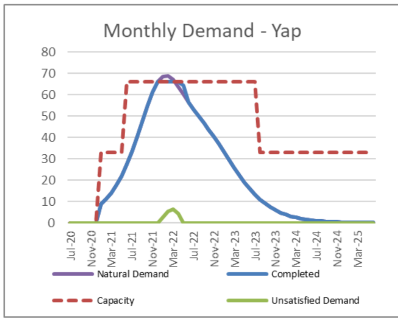
The connection will include fiber from the communal network to an optical jack point inside the customer's premises. The customer will connect an optical network terminal (also called a Residential Gateway / WIFI Router / Modem) that is provided to them by their RSP into the jack point. OAE does not plan to charge an install fee.

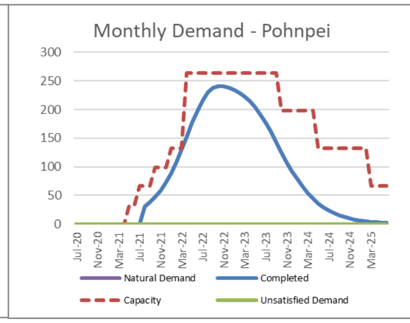
The connection from the communal infrastructure in the street will either be underground or aerial depending on what infrastructure is deployed in the street. The objective is ensuring the optimum mix of cost, reliability and aesthetics.

OAE is looking to engage a contractor in each state (or a single national provider if appropriate) to connect homes to the communal network. Ideally OAE is looking for a standard price for each standard[3] connection.

Based on the business modelling and forecasting that OAE has completed, it expects demand to be slow initially as service providers and customers gain confidence in the new network and its processes and then to increase before slowing. Managing the transition through the different demand phases will be one of the challenges for whomever OAE contracts with to deliver the service.

[3] Most connections will be straightforward connecting a single dwelling home to the communal network in the street. OAE expects there to be a number of more complex installations (for example to multi-dwelling units or remote villages) that will require a time and materials-based approach.





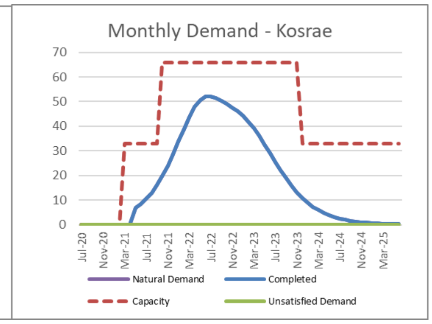


Figure 5 - Projected take-up rate, and expected number amount of installation capacity required in each state. It is expected that a crew of two people will be able to complete 2 installs per day. Adjusting for working days and the fact that they won't be able to run at full efficiency for practical reasons means that each crew is expected to complete 33 installs per month. Using that yardstick, Yap and Kosrae will need a peak of two crews, Pohnpei is expected to need a peak of eight.

OAE has chosen a medium uptake scenario. Currently there is no engagement plan with Telecom to migrate their customers across which would have to be true for a faster migration to fiber. The medium scenario assumes that new entrants enter and move customers relatively quickly to fiber.

Over time the work will transition from connecting new customers to fixing faults. The workload for faults is expected to be considerably lower than that associated with copper networks. Fiber networks are much more fault resistant than copper networks as they are not affected by water ingress to the same extent. The graph below shows forecast new connections peaking, with expected fault level rising as the network grows.

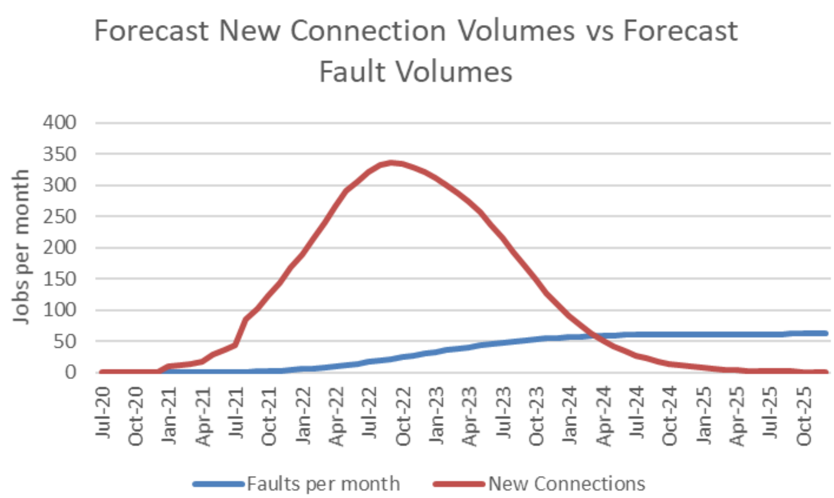


Figure 6 - Forecast new to network connections and faults over time. The long-term workforce is expected to be much smaller than that required to manage the peak connections.

There will be a small amount of additional ancillary work expected. Tasks like providing proactive maintenance, swapping service customers between different service providers, and managing network configuration changes for service providers will all be required. However, this is expected to only require one or two staff per state.

6.4. How the communal network is proposed to be built

High level architecture and assumptions

The network is to be built as an open-access standalone overlay to the existing copper network.

The network radiates out from the central office or telephone exchange. These are to the left of the picture below. Fiber cables or ducts will leave the central office to fiber flexibility points (FFPs). These are above ground roadside cabinets that GPON splitters are installed to "share" the fiber between multiple end customers and service providers.

Fiber access terminals (FATs) are the last link between the connection to the individual premises and the communal network.

The goal of the communal network build program is to leave the network at the boundary to each premises, ready and able to be connected on demand with a ½ day installation required to get it from the boundary to the inside of the end customers home or office.

The fiber program is split between communal build and customer connection because of the different skills and challenges in involved in the different parts. The communal network build is in the roadway (or immediately adjacent) and needs to be completed as quickly as possible to minimize disruption and ensure that the network is available to as many potential customers as quickly as possible.

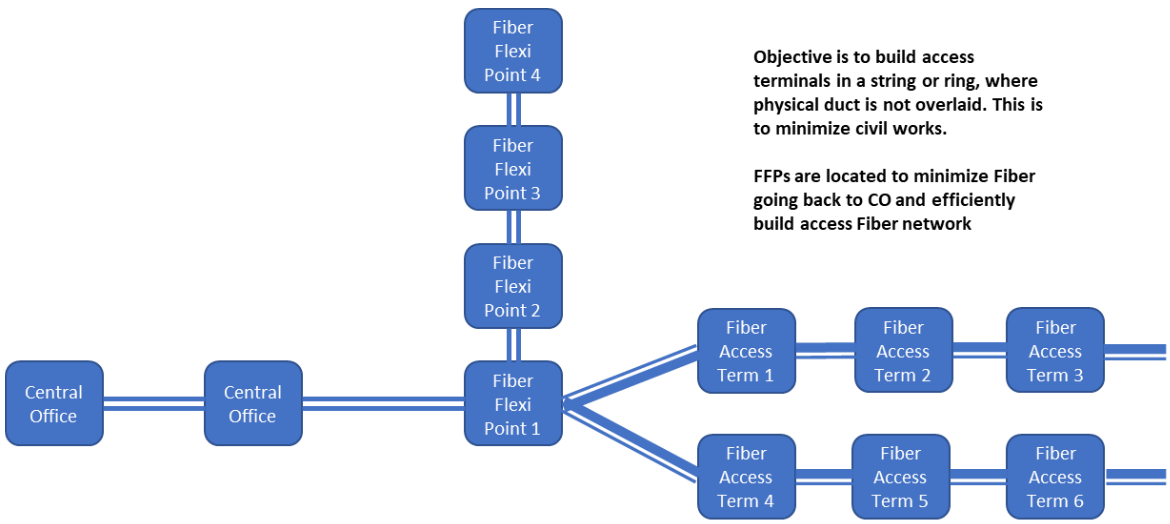


Figure 7 - High level fiber architecture

The design goal is that each Fiber Flexibility Point serves a maximum of 288 end connections, each FAT connects 48 individual connections

Central Office

Each Central Office will have to have an Optical Fibre Distribution Frame (OFDF). This provides the interconnection between the access fibres and service providers equipment.

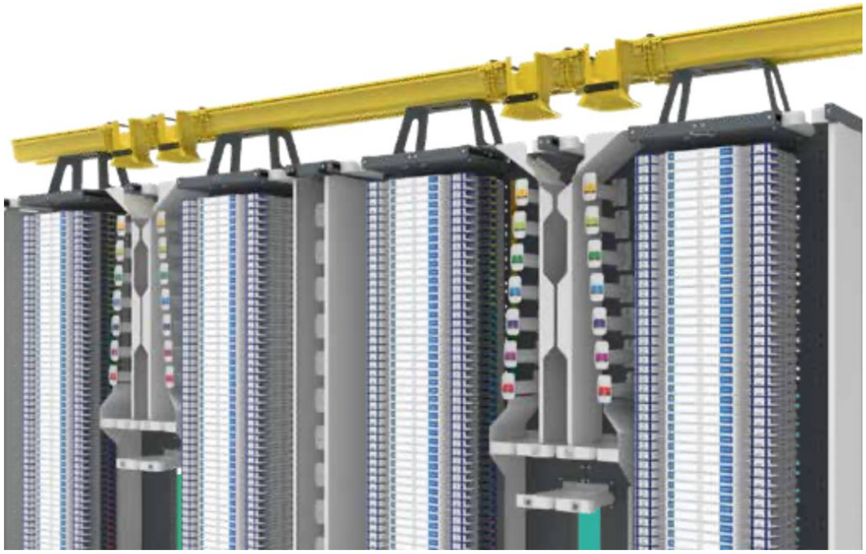


Figure 8 - Commscope FACT Optical Fibre Distribution Frame for Central Office. 2680 connections per frame in a normal cross connect configuration

Distributed Fibre Flexibility Points mean that he main optical distribution frame in the Central Office can be relatively small compared to the total number of end customers supported.

Pohnpei is likely to require 3 based on a 20km transmission limit. Chuuk will require more detailed planning based on how the inner islands are linked.[4]

Fibre Flexibility Point

The Fibre Flexibility Point is the key building block of a multi-purpose open access layer 1 fibre network. It is the point where every premise has a direct connection to and allows the option between service providers and multi-point or point to point options.

To best meet the aims of the OAE network, service set and desired industry structure, an intermediate sized cabinet fibre flexibility cabinet has been chosen. This provides the best compromise between providing the most flexibility with a lower fibre runs compared to running all fibres back to the central office.

This is a passive, street side cabinet that terminates individual customer fibres into either a direct fibre back to the central office for a point to point service, say for government or mobile backhaul or into a splitter for a GPON based service.

The cabinet is to be connectorized. This means that swapping between service providers or swapping between a point to point service is quickly and requires no special tools. The FFP is expected to be above ground, providing easy access. Some airblown fibre may be directly connected to the cabinet, that would be where the cabinet acts also as the Fibre Access Terminal for premises immediately nearby.

[4] If initial capacity is made with fibre cables to each inner island, then it may make sense to host the central office remotely, say on Weno, rather than have one on each island. It would make it considerably easier for service providers.

The FFP would connect to six Access Control Joints. Access Control Joints are where the underground or aerial distribution groups are distributed from the feeder to the final distribution fibres.

Figure 9 – Example of Eaton Bullet Cabinet for FTTH in situ in Auckland NZ. They are lower cost than FTTN equipment because they have no power requirements. The cabinets are completely passive and low maintenance as a result.

Fibre Access Terminal

A control joint is required to connect between the feeder fibre and the final distribution fibre.

Where underground final distribution is used for an access group, then this is the location where 5/3.5mm microduct is used to connect to the premise. It provides an interface between the high-count fibre cables deployed in 12/10mm feeder duct.

Where aerial final distribution is used for an access group, then this is the interface between the underground feeder and the aerial distribution group.

Figure 10 - Channell Flash 9 Fibre Control Joint as an example. This is deployed underground in Channell BULK pit. Left picture is joint opened and raised for access; right picture is how it presents in the field. The pit is preformed HDPE plastic and is simply dug in and placed on an aggregate base.

Building the network underground

Between core fibre flexibility points and central offices and then between central offices (for Pohnpei) the network should be underground to provide sufficient resiliency against weather events and other risks. The precise mix though will depend on costs and OAE will make a pragmatic trade-off.

Rapid trenching technology with micro ducts has been identified as the most appropriate technology for the environment. The preference for underground and not having access to existing duct infrastructure means that rapid trenching is expected to be the quickest, lowest cost and least disruptive approach. Rapid trenching is ideally suited to microduct deployment as microducts allow the use of the smallest possible cut normally associated with direct buried cable installation whilst retaining the flexibility of ducts. Ducting is preferred to direct buried as it allows for future changes in network configuration and growth.

Lead-ins may either be underground or overhead based on what is currently being deployed for copper connectivity and what is most practical.

Airblown is the preferred approach for underground

For underground infrastructure the preferred approach is to use airblown fiber. This is for core, feeder and distribution fiber. There are no existing ducts that are able to be used and a ducted architecture is preferred to allow for straightforward future upgrades at low cost. An important attribute of airblown infrastructure is that it can be deployed by a relatively low skill based civil team.

For the communal build of the network, the main contractor is essentially placing ducting approximately 400mm underground. The proposed duct comes rolled on a drum in 1km lengths and is rolled into the trench.

Figure 11 - Hexatronic Tight Protected Microduct products as examples. On the left are the Ribbonet products with the larger duct having 26 5/3.5mm ducts for individual premises and a single 12/10mm duct for feeder or core fibre. The overall duct is 38mm in diameter resulting in a low impact installation compared to traditional ducting. The drum on the right is a 500m drum of single ruggedized Microduct. This product can be shallow buried, attached to walls, fences or other structure and used for connecting individual homes or villages to the main duct. The smallest tubes support airblown fibre units between 2 to 24 fibres, the 12/10mm up to 192 fibres.

Lead-in cabling deployed directly from this architecture whether underground or aerial would be airblown.

Microtrenching technology can make the build process very quick

Rapid trenching technology to a 450mm depth would appear to be both viable and the most efficient approach to the conditions.

Improvements in the process and capability of rapid trenching mean that it can achieve fast, low cost and low impact deployment. Machines can build at around 400 metres per day at 450mm depth, manage simple curves and work hand in hand with microduct technology.

Microducts require a narrow trench (approx. 65mm for a ~40mm duct) that can carry ducts for both access and core transport. Microducts are semi flexible, this means that they can follow curves which when combined with the micro trenching means a far quicker process compared to traditional 100mm HDPE ducting and either drilling or backhoe.

The full process, including ground penetrating radar, back office analysis of the radar images and marking out has become well developed and very efficient compared to traditional approaches.

Hard surfaces are reinstated with a one pass mortar which is both quick and strong.

For underground build, OAE expects potential contractors to investigate how they could use microtrenching as it will produce a quicker, less disruptive approach.

Figure 12- Marais Sidecut SC3C - can achieve 500m per day in a wide range of terrain. 200km of fibre optics has been deployed in New Zealand by Marais to date.

A small crew using two machines and appropriate spares in country could easily complete FSM build requirements.

Where utility poles make the most sense

For situations where aerial is the best approach, (where it is not possible to go underground for cost or other reasons) All Dielectric Self Supporting (ADSS) fiber is to be used as it allows increased flexibility for closer colocation with power infrastructure. Individual fibers for each house/ premise would then be built back to a fiber flexibility point.

This solution is not as flexible as the underground airblown solution but the fact that aerial cables can be replaced or augmented relatively easily means that the inherent flexibility of airblown is not required.

Aerial fiber does require experience with aerial infrastructure to deploy. ADSS fiber can be placed in the electricity envelope which means it can be higher (and better protected) than in the traditional communication infrastructure area.

Aerial architecture will be built for easy and safe provisioning. The preferred approach is a connectorized terminal on each pole which just requires an individual connection to be plugged in.

Premises boundary point – how the network is left "ready to connect"

The network is to be built so that the fibre is made available at the boundary point immediately adjacent to the premises to be connected. The network is left at the completion of the network build stage in such a state that relatively low skills are then required to connect each individual premise. The network should also be relatively isolated from the rest of the network such that connecting to it presents little risk to other customers. It is desirable that any civil work is kept to the barest minimum.

For underground communal network delivery, each property / service point would have a microduct tube left available at the boundary. In soft conditions, this could just be a tube and a marker post, or in hard surfaces a hand hole, or a partial install (with the property owners' consent).

Figure 13 - Example of network boundary marker for underground microduct. Marker locates duct and provides easy access for connecting service.

Where aerial deployment is used; a connectorized enclosure is deployed as part of the build. This means that provisioning a service is simply connecting a pre-connectorized service lead into the enclosure.

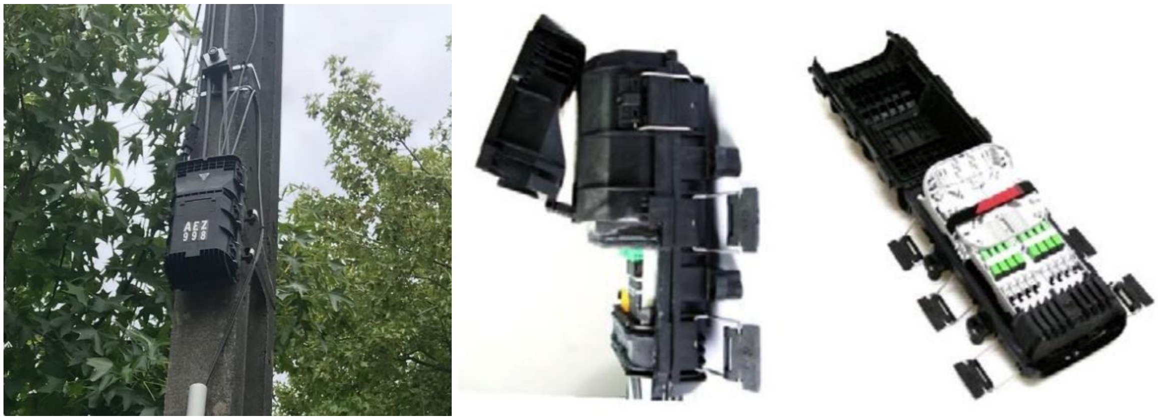


Figure 14 - Connectorized Aerial Closure. Commscope OFDC-B8G, on the left as deployed on a power pole feeding homes and a remote access terminal on a pole across the street. On the right are the views showing the internal connectors; suitable for 8 homes with up to 2 fibres each. A Remote Access Terminal (RAT) is available as a companion product that provides a quick road crossing to supply 4 homes on the other side of the street. This is pre-connectorized and can be installed on demand.

6.5. Urban vs rural

Whilst each state is unique and different, they follow a general pattern. An urban / built up area (for example Colonia, Kolonia and Weno) which follow a fairly normal pattern of paved streets and relatively dense buildings and rural which is everything outside of the built-up areas. A clear set of “tools” can be used, that are common, but will be applied to each given area based on the unique circumstances of that particular section.

Urban Areas

These are characterized by having multiple existing services present (water, power, copper telecommunications, sewerage, cable TV), hard surfaces (roads and footpaths) and often little apparent spare space. Approaching these in the traditional manner to build brand new underground trenches with traditional ducting will be expensive.

The assumption is that rapid trenching technologies will be used. Deploying microduct infrastructure 450mm below the surface. This gives a low cost, quick deployment with sufficient protection against damage.

Figure 15 - Examples of Urban area civil environment.

Alternatively, provided appropriate pole share agreements could be obtained, would be to use aerial distribution from the existing power infrastructure. However underground, all other things being equal is still preferred.

Rural Areas

These present a simpler build proposition. There are fewer services to content with and on the whole more space to deploy new infrastructure. One critical issue is that in detail, each section of road can have quite different conditions from the next. Conditions ranged from good roads with wide, clear easements, to others that faced the coast and had little room.

Aerial will be the simplest and quickest deployment method, but Micro Trenching is expected to be viable, especially as most rural routes will include a transport / aggregation network requirement as well as access. There is a desire to place all transport / aggregation fibers underground. If the transport is going underground, then building the access underground is the expected approach.

Side roads, off the main transport / aggregation paths, will be most suitable for aerial feeder distribution.

Where road infrastructure is being replaced new underground infrastructure is recommended as it is very low cost to deploy in a traditional trench before the road surface is reinstated.

6.6. Connecting each customer to the communal network

The goal of the communal build is to leave the network ready to connect. This means that a crew of two people should be able to do all the work required to connect between the communal network and the inside of the home in half a day.

This is important as the path to getting fiber for each individual home must be easy and present the least inconvenience possible.

Part of the process of connecting the customer will be to ensure that they are happy with the proposed build and process before work commences. The technicians will have to be happy that all appropriate and relevant permissions have been given before starting work. It is expected that permission to proceed is obtained by the service provider signing the end customer up to the service.

The connection takes the communal network from the boundary point (either an underground market or a terminal on a utility pole) and brings it into the home.

The following is the initial high-level approach, the actual solution will refine as detailed designs are completed.

Drop Lead

The drop lead to each premise provides 2 fibres per premise from the boundary point in the road to the home or office. This allows for future upgrades and multiple services. Only one fiber needs to be terminated to provide initial service.

For underground, air blown infrastructure, an air blown 2 fibre unit is anticipated. This would be fusion spliced at the FAT and to a pigtail in the premises. The fiber connection at the FAT links back to the FFP and the pigtail provides connectivity between the in premises wiring and the wiring in the street.

Aerial service leads will be pre-connectorized for connection to the Aerial Closure on the utility pole and then fusion spliced to a pigtail in the premises. Pre-connectorized would come in factory set lengths for aerial distribution. There may be a requirement for a fixed fibre solution to solve for any underground requirements that are served from an area where aerial distribution is chosen.

It is expected that the technicians would require fusion splicing equipment and training. OAE is evaluating alternatives using connectorized solutions they may work as an alternative.

Connection inside the home or office

Each home or office will have one 5/3.5mm tube allocated to it for airblown deployment. This allows two fibres to be blown for normal connections and the ability to upgrade to up to 24 fibres.

OAE is yet to confirm the precise design and an external termination point (affixed to the outside wall of a building) may or may not be required. However, the building entry point must meet weather tightness requirements in a high rainfall climate, and it may be appropriate based on the systems used to have an external termination point to separate between the external drop cable (and duct where airblown is used) and the internal building cabling.

The service must be terminated on an internal termination point that provides a SCA connection. This provides a simple socket where the service providers ONT (optical network terminal) plugs in. It will need to be located close to mains power.

Figure 16 – Examples of Hexatronic Internal Termination Point, Hexatronic External Termination Point and External Termination Point in situ

More complex installations in multiunit dwelling or office buildings

FSM does have a number of residential and commercial multi-dwelling units (both low rise residential and commercial). There are also several campus type environments (Hospitals, College of Micronesia, Government Offices) and residential communities where there is further distribution required.

6.7. Connecting rural settlements – from the main road to the village

Rural villages and settlements tend to be a relatively short distance from the main road. They all were different in terms of specific geographic features, but common in terms of the approach that would be needed to connect them.

The initial plan is that connecting a village like this would not be part of the initial communal network build. This is because the build of the network off the main road to connect to a specific village or family group would need to the active engagement of that village. It makes sense to do these as a one by one activity rather than as part of a scheduled main network build.

It is more appropriate to manage these as a build on demand approach rather than through a managed time bound programme that the communal build will follow.

There may be different approaches, e.g. underground or aerial but they would need to be agreed with the village stakeholders on a one by one basis.

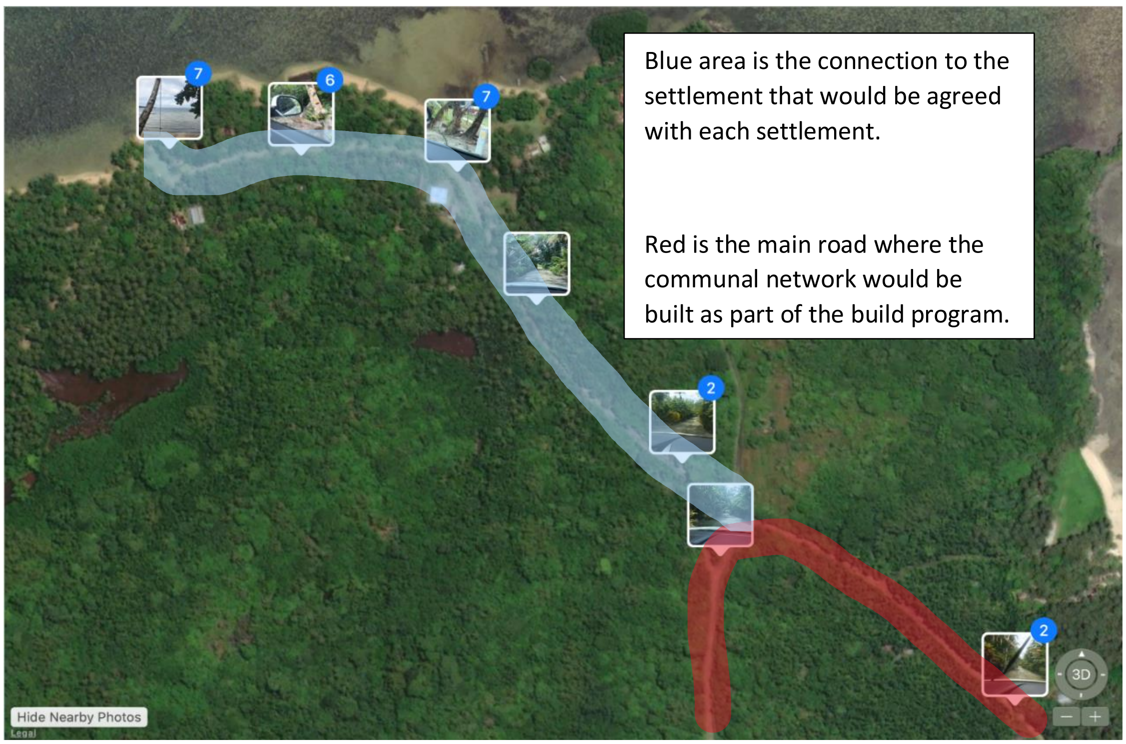


Figure 17 - Example of village at the northern tip of Yap

Figure 18 - Road to village after leaving the main road. The earthworks to the right are preparations for a shallow buried water main. A fibre install would be much less intrusive.

The same approach could be used where there aren't existing vehicle access ways. This could be as straight forward as a drum of ruggedized 5 mm microduct that the village installs in the way they feel works best. In some sections it would be shallow buried, others, attached to the sea wall. Ruggedized microduct is just a plastic tube. It requires limited technical capability to install and is better done by someone with local knowledge and understanding. The local community could install the microduct themselves and then the installing technician with the technical skill required to blow the fibre through and then connect it to the fibre network.

Appendix 1 – Premise counts

Note that these are approximate and should be considered indicative

Key statistics for Yap main island:

2010 Census Count of Homes	1,680	Only residential properties counted
Count of Open Street Maps Buildings	1,927	Higher as incudes non-residential, and includes out-buildings, but satellite based analysis means that a number of buildings have not been counted as they were obscured.
Count of Electricity Meter Points	1,874	Starting assumption for desktop based planning. Correlation with request for electricity and broadband is high.
Count of Modelled Buildings from Pacific Geo	1,600	Rough approximation.
Main Roads	47 km	
Secondary Roads	113 km	Note that this includes paths and tracks

Key statistics for Pohnpei Main Island

2010 Census Count of Homes	5,970	Only residential properties counted
Count of Open Street Maps Buildings	2,716	Missing large portion
Count of Electricity Meter Points	5,159 (2010 census houses with power) To update with actuals from Utility	Recommended starting assumption for desktop based planning. Correlation with request for electricity and broadband is high.
Count of Modelled Buildings	9,465	Rough approximation
Main Roads	80 km	The main ring around the island
Secondary Roads	251 km	Includes the streets of Kolonia and the inland roads and tracks.

Key statistics for Kosrae

2010 Census Count of Homes	1,143	Only residential properties counted
Count of Open Street Maps Buildings	641	Missing large portion
Count of Electricity Meter Points	1,079 (2010 census houses with power) To update with actuals from Utility	Recommended starting assumption for desktop based planning. Correlation with request for electricity and broadband is high.
Count of Modelled Buildings	426	Missing large portion
Main Roads	44 km	
Secondary Roads	34 km	

Key statistics for Chuuk lagoon [not included within scope of work]

2010 Census Count of Homes	5,444	Only residential properties counted
Count of Open Street Maps Buildings	8,629	Higher as incudes non-residential, and includes out-buildings, but satellite based starting point will miss some
Count of Electricity Meter Points	To be updated	Work assumed to be completed at the same time as electricity build on islands of Inner Lagoon
Count of Modelled Buildings	5,442	Rough approximation
Main Roads	13km	All in Weno
Secondary Roads	96 km	Except for Weno, they are all pedestrian paths and tracks