Orkney Islands Digital Infrastructure Investment Case

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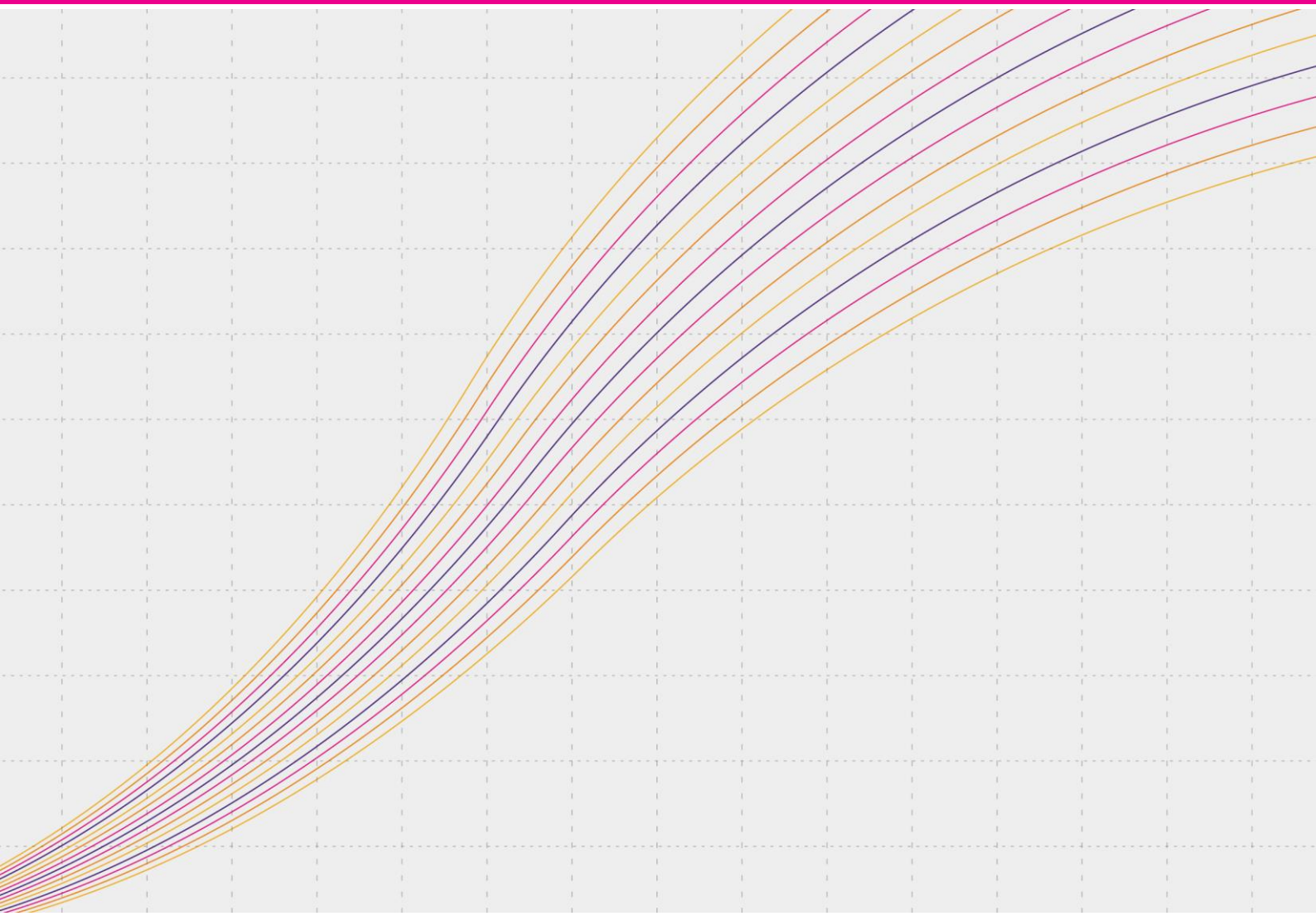

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The firm applies consulting experience, industry knowledge, rigorous analysis, and its clients' understanding and perspective to address challenges and opportunities across regulatory, policy, commercial, and technology domains.

Our assessment

We were engaged by Orkney Islands Council (OIC) to support development of a digital infrastructure investment case for the region (project reference: OIC/PROC/1329).

Our focus has included network planning and development of commercial options, to support a target of 100% gigabit capable connectivity for the region.

With our assessment, we have taken into account requirements across both the public and private sectors.

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Executive summary

Our scope with this paper has been limited, consistent with our contracted brief, to focus on development of an investment case, supporting 100% gigabit capable broadband connectivity for Orkney.

The Orkney Islands is part of the United Kingdom: an archipelago of small islands located around 10 miles off the north east coast of the Scottish mainland in the North Sea. The Islands are home to a new £65m hospital, plus a number of schools, colleges, and public offices. Major economic sectors include health and social care, agriculture and fishing, and public services, with tourism cutting across. Virtually all of the region is classified as 'very remote rural', with around 13k premises located across 990km^2 of land area. Around 35% of these are located in the main town of Kirkwall.

Orkney is currently ranked as one of the UK's most poorly served broadband areas, especially in terms of gigabit per second broadband speeds.

Less than 2% of Orkney premises are able to access gigabit rates (via Openreach FTTP), with around 66% of premises able to access superfast (30Mbps), and c. 20% of premises accessing just 10Mbps or less.

Market scale and rural location should not be impediments to gigabit access.

The pandemic has made it very clear that remote access to modern broadband is essential, and it is well-known through numerous professional studies that digital broadband connectivity is an enabler for economic growth in modern service-based economies. Further, any impediment to fixed access broadband roll-out is a direct inhibitor to deployment of 5G and modern wireless networks as these need high speed links for core network connectivity.

With the remote location of Orkney Islands, backhaul costs are a major factor (i.e. cost of data conveyance from Orkney Islands to main internet backbone colocation hubs in Scotland).

Despite the promises of mass connectivity with the major gap funding initiatives from Government: R100 and Project Gigabit, these have as yet failed to deliver full gigabit connectivity results for Orkney's residents.

Consequently, proactive dialogue with Government is required, supported by an investment case meeting a clear gigabit capable coverage ambition – set at 100% of premises by Orkney Islands Council.

Some public sector needs in Orkney are met via the SWAN public services network which is being tendered for renewal[1]. SWAN is supported by bitstream access services, in the same way that all other segments are (but implements particular security and quality standards through use of SD-WAN technology). Adequate quality in access network bitstream performance is therefore a key issue across all segments. Other public sector needs are met with FWA or FTTP access links which connect to OIC's main office which acts as a SWAN hub.

The UK market is influenced by a number of government initiatives and regulatory actions. Broadly, these include developments in regulatory pricing affecting FTTP products, gap funding to support build-out in more rural areas, and new spectrum licensing and access – supporting regional access for wireless systems in new radio bands.

[1] SWAN connectivity is provided to OIC's main office, plus 15 schools.

We recommend a hybrid technology approach using a combination of full fibre FTTX to local hubs, and gigabit capable wireless FWA from local hubs to end user premises.

With such a hybrid approach, we estimate a total capital outlay requirement of c. £11.4m, covering new build on FTTX fibre for FWA hubs and FWA site deployments. With take-up towards 100% over 5 years, given the remote location of the Orkneys, and the likelihood of little or no infrastructure competition,

Our investment case assessment shows that a sustainable business model is feasible, subject to access to sufficient capital funding – which is likely to require gap funding or significant subsidy.

Operational costs will be driven significantly by backhaul charges. Therefore, we have assumed use of long distance submarine cable based leased line bitstream services to provide connectivity between a main exchange point on Orkney and an IP peering colocation site based in Aberdeen, Scotland. Resilience could be provided at additional cost, via overland backhaul circuits. Given the need for development on wayleaves and rights of access, we would expect a complete build programme to take around 4-5 years. This however is subject to access to adequate capital funding. We recommend that administrative issues are examined, as this is longer than we have seen in other regions, with similar scale.

Key recommendations:

- We recommend that public services are maintained via the SWAN network, and that focus is placed on developing gigabit capable connectivity to premises, with supporting infrastructure. As access connectivity is improved, we would expect the SWAN network to make use of this over time.

- As a priority, OIC should look into reports of inefficiency in planning and administration with its own processes, relevant to roll-out of telecoms infrastructure.

- We see value in OIC taking a leadership role in roll-out of a market awareness campaign to end users, to drive up awareness of the social, economic, and commercial benefits of connectivity for the region. This should be made region-specific, but could usefully leverage previous activities such as the work done under UK GigaTAG[2]. This will promote take-up of digital services, and a sustainable telecoms business in region.

- We see OIC as facilitating telecoms infrastructure investment and stimulating market demand, rather than taking a role as a telecoms operator itself. Precedent suggests that the latter can lead to conflicts with private operators to the detriment of the market. Local intervention can, however, be valuable in some cases (e.g. driving down backhaul charges). Operation is best carried out by commercial operators in our view.

- We recommend that OIC takes a leading role in facilitating the development of new local FTTX and long distance backhaul connectivity, leaving access network development focus to the market (supported by gap funding).

- Development of proactive dialogue with both the Scottish and UK Governments will be important, to position a strong case for gap funding for Orkney. We note, however, that the R100 and Project Gigabit programmes come with a level of due process to be followed, though Governments actively encourage dialogue. Dialogue with Openreach, Cloudnet and other interested telecoms infrastructure-based operators will also be important – to establish committed build levels.

- It may be prudent to assess how phased build-out of gigabit connectivity could bring most significant benefits at an early stage. We recommend that build areas are targeted with consideration of scale of social and economic benefits that could accrue with access to new high quality broadband services.

[2] See: http://www.broadbanduk.org/2021/06/17/the-gigatag-publishes-its-final-report/

1 Background

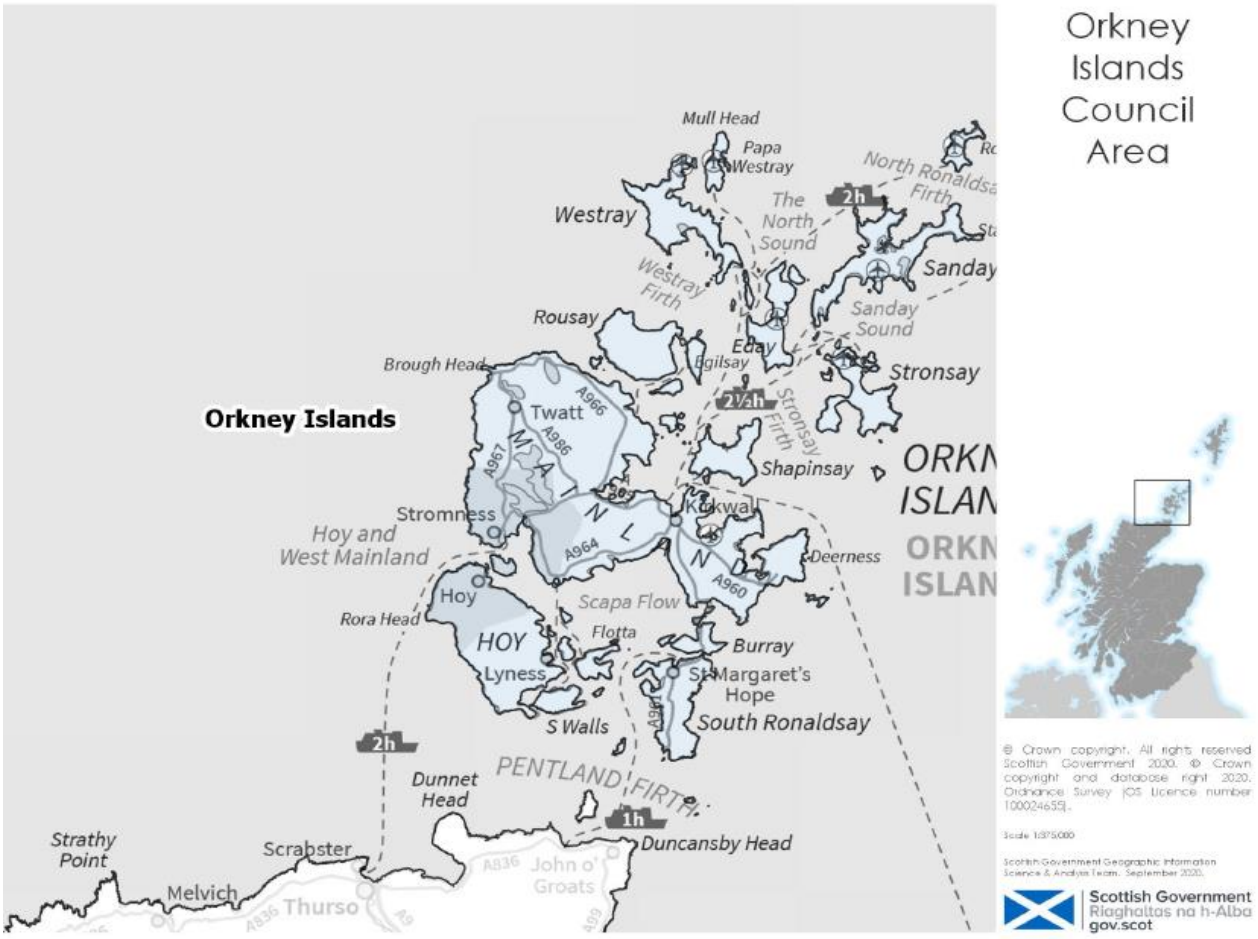
1.1 The Orkney Islands

The Orkney Islands (see Figure 1.1) is part the United Kingdom: an archipelago of small islands located around 10 miles off the north east coast of the Scottish mainland in the North Sea, across the Pentland Firth. Virtually all of Orkney is classified as 'very remote rural'[3], with the exception of Kirkwall ('very remote small town').

Key industries on Orkney include renewable energy development, tourism, farming, manufacturing, food production, and fisheries and aquaculture. Major economic sectors include health and social care, agriculture and fishing, and public services, with tourism cutting across[4]. The islands are home to a number of schools and colleges covering the full range of education to tertiary level. There is also the new £65m Balfour hospital, opened in 2019, located in Kirkwall and managed by NHS Orkney.

Population stands at c. 22,400[5], total dwellings at c. 11,442, and c. 1,600 business sites, with a significant proportion of total Orkney population resident around the main town of Kirkwall.

Figure 1.1: Map showing the Orkney Islands[6]



[3] https://www.gov.scot/publications/scottish-government-urban-rural-classification-2016/pages/2/
[4] https://strathprints.strath.ac.uk/75705/1/FAI_2020_Orkney_Islands_Economic_Review.pdf
[5] https://www.nrscotland.gov.uk/files/statistics/council-area-data-sheets/orkney-islands-council-profile.html
[6] https://www.gov.scot/publications/local-authority-maps-of-scotland/

1.2 Digital connectivity: current state

Orkney is currently ranked as one of the UK's most poorly served broadband areas, especially in terms of gigabit per second[7] broadband speeds. Less than 2% of Orkney premises are able to access gigabit rates (via Openreach FTTP), with around 66% of premises able to access superfast (30Mbps), and c. 20% of premises accessing just 10Mbps or less (typically due to long copper line distances, line and duct quality, and/or challenging terrain in some areas).

According to current plans[8], Openreach will install some FTTP fibre in Orkney. Coverage is expected in Kirkwall, and other areas. At a conservative level, Openreach FTTP deployment will cover around 35% of all Orkney Islands premises (by around 2026, according to Openreach plans).

Aside from Openreach, only limited alternatives presently exist. Modest (10Mbps broadband) packages are available from Cloudnet – a regional infrastructure-based WISP altnet – which provides FWA solutions and has been an innovator using TV White Space (TVWS) technology[9]. With Openreach as the majority provider of wholesale broadband services in Orkney, and with its limited infrastructure, there is little alternative for end users: retail choice on the Openreach network does not, in reality, provide much choice at all.

Orkney's public service users (including the hospital, council, and schools) use the existing SWAN network services (currently administered by Capita plc). Premises access to the SWAN network is enabled via 'standard' broadband IP connections, though these are currently ordered and installed under the main SWAN contract. The SWAN network includes a purpose built point-to-point microwave backbone across the islands[10,11].

Market scale and rural location should not be impediments to gigabit access. The pandemic has made it very clear that remote access to modern broadband is essential, and it is well-known through numerous studies[12,13] that digital broadband connectivity is an enabler for economic growth in modern service-based economies.

Further, any impediment to fixed access gigabit broadband roll-out is a direct inhibitor to deployment of 5G and modern wireless networks as these need gigabit links for core network connectivity.

All of this leaves no firm commitment for 100% gigabit access network coverage for Orkney residents.

1.3 Submarine fibre cable connectivity

Orkney (Skaill) is currently connected to the Scottish mainland (Dunnet Head) via the 'Northern Lights' subsea fibre cable, operated by BT since 2008, with an expected end of service by 2033.

[7] Gigabit per second broadband speeds (or higher) are widely seen by industry and UK Government as the target level for modern connectivity. This evidenced clearly throughout the UK with billions of pounds now being invested in full fibre demand, and Government's own £5bn Project Gigabit. At an international level, some countries are attaining yet higher broadband levels (e.g. in Switzerland, 10Gbps broadband is becoming the national standard).

[8] https://www.openreach.com/fibre-broadband/where-when-building-ultrafast-full-fibre-broadband

[9] TVWS technology makes use of unused TV radio bands to provide broadband access services. Whilst regarded as innovative, the technology is generally not seen as a mainstream solutions meeting modern broadband requirements. Other fixed wireless access (FWA) technologies are typically deployed when gigabit capability is demanded.

[10] The SWAN public service network (PSN) contract includes a number of services available to public sector users, with economy of scale as a key concept. At a network architecture level, SWAN is built upon a network of networks (NoN) concept with central core capability (including domain management, core data network, BSS/OSS), with end to end service assurance (service levels, virtual seamless network regardless of underlying physical networks) and network security implemented via a secure core, adherence to common standards, and managed access.

[11] https://webarchive.nationalarchives.gov.uk/ukgwa/20100304104621/http://www.cabinetoffice.gov.uk/media/142379/vdn_report.pdf

[12] Koutroumpis, P: https://www.ofcom.org.uk/research-and-data/telecoms-research/broadband-research/economic-impact-broadband

[13] Corden, I: https://www.5gruralfirst.org/wp-content/uploads/2019/10/5G-RuralFirst-New-Thinking-Applied-to-Rural-Connectivity-1.pdf

Orkney is also served by the Shefa-2 cable (Manse Bay and Ayre of Cara in Orkney to Banff in Scotland), operated by Shefa (Faroese Telecom).

Some resilience in these connections exists, with two connections to UK mainland and also to Denmark via the Shetland / Faroe Islands subsea network, although there is some history of cable breakages due to fishing trawlers and ships' anchors operating in the region.

Additional subsea fibre optic cables serving Orkney are expected to be laid during 2022, as part of the R100 programme; this includes connectivity between a number of the islands.

1.4 Gap funding situation

Despite the promises of mass connectivity with the major gap funding initiatives from Government: R100 and Project Gigabit, these have as yet failed to deliver gigabit connectivity results for Orkney's residents.

The R100 programme has been delayed with legal challenges, and can be seen as insufficiently ambitious – with its original focus on superfast connectivity. Some would also argue that the scale of gap funding was insufficient – given the economic challenges in building FTTP in rural areas of Scotland. There remains continued doubt as to whether the R100 programme will deliver on gigabit needs in Orkney[14] (R100 only pledges to deliver on superfast needs).

UK Government's Project Gigabit[15] has also attracted its share of criticism, with concerns from investors and altnets on overbuild potential, changing plans, and procurement complexities. In addition, the programme's current focus is largely towards supporting FTTP roll-out in England.

Whereas Government vouchers are an option, and these have been well-received across the UK rural market in general – given their flexibility, there are eligibility issues: the R100 SBVS[16] provides only limited gap funding if superfast connectivity is planned, and none if superfast is in place. The UK Government's GBVS[17] goes some way further, offering funding if connectivity is less than 100Mbps and no gigabit network is planned and funded. Subject to eligibility, GBVS and SBVS vouchers can be 'stacked' to provide funding of up to £6,500 per residential premises and up to £8,500 for business premises. Perhaps most crucially, voucher schemes are supplier-led: they depend on suppliers' willingness and appetite to build with gap funding (and some commercial interest).

Commercial interest levels will depend on investment case viability and available resources, and commercial interest will naturally fall to more populated areas, where investment cases are more secure (unless gap funding is committed).

This situation points to a need for proactive dialogue with Government, if regional needs are to be met.

Specifically, dialogue to secure sufficient gap funding will be required.

[14] https://www.orkney.gov.uk/Files/Committees-and-Agendas/Policy-and-Resources/PR2021/SPPR19-05-2021/I03_Orkney_Digital_Strategy.pdf
[15] https://www.gov.uk/government/publications/project-gigabit-delivery-plan-autumn-update
[16] https://broadband.gov.scot/
[17]

1.5 Regulatory issues

1.5.1 Fixed access regulation

From a regulatory standpoint, there are challenges too. Since Ofcom's publication of the Wholesale Fixed Telecoms Market Review (WFTMR[18]) in 2021, there has been substantial concern from industry as to lack of support for altnets and their investors, especially in 'Area 3' (more rural areas), despite their spending billions of pounds on new network build programmes. This essentially results in potential pressures for altnets with their investment models.

More recently, Ofcom has cleared Openreach's 'Equinox' offer[19], which introduces price discounts for its FTTP bitstream products at the wholesale level. Whilst on the one hand this has potential to drive down retail prices to benefit end users (as reduced FTTP wholesale prices will enable reduced FTTP retail prices), it could also drive some altnet providers out of the market (as they may not enjoy economies of scale in building networks that Openreach has access to), ultimately affecting consumers and limiting competition. Legal challenges on 'Equinox' are ongoing and it remains to be seen whether Ofcom will shift its position, although it seems unlikely.

Openreach is unlikely to build in all regions, and its executives have publicly stated that they do not see themselves as the only provider of FTTP infrastructure. No doubt, Openreach will build where it sees fit, and altnets will continue to have an important role in the market.

A more effective course of action for ISPs in the near term will be with novel commercial models, and right technologies for the job, supported by relevant areas of policy and regulation.

1.5.2 Wireless sector regulation

On the wireless side of the industry, things are rather brighter.

Since Ofcom published its Wireless Innovation Statement in 2019[20], commercial wireless operators have sought to exploit regional spectrum sharing with a variety of new commercial models. These include wholesale 4G mobile access via neutral hosts, and deployment of leading edge gigabit FWA solutions – enabled with 5G chipset based products operating in the 3.8-4.2GHz band, as the supply chain continues to develop.

Ofcom has further set out its broad approach towards spectrum management in a recent statement[21]. Licensing for FWA equipment in the 26GHz band is expected later in 2022.

These developments enable commercial deployments of novel fixed wireless access radios capable of supporting gigabit speeds over link distances of several kilometres, with appropriate system designs.

[18] https://www.ofcom.org.uk/consultations-and-statements/category-1/2021-26-wholesale-fixed-telecoms-market-review
[19] https://www.ofcom.org.uk/consultations-and-statements/category-3/openreach-proposed-fttp-offer
[20] https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation
[21] https://www.ofcom.org.uk/__data/assets/pdf_file/0017/222173/spectrum-strategy-statement.pdf

1.6 Market dialogue

1.6.1 Dialogue with Openreach

We are grateful to BT and Openreach (Robert Thorburn, Partnership Director) who supported dialogue for this paper. We discussed a number of areas including FTTP build plans for Orkney, backhaul, and gap funding. We appreciate that some areas remain commercially sensitive, and that it was not possible to discuss these. Key points from our dialogue are listed below:

- In some cases, the R100 programme is supporting FTTP build-out, including areas in Orkney Islands (see Figure 2.1). Openreach has committed FTTP build plans for Kirkwall.
- The R100 programme is already supporting new subsea cables[22], including in Orkney.
- Investment initiatives should be supported by an awareness campaign led by OIC targeting end users, to clearly lay out the social, commercial, and other benefits that come with gigabit connectivity – to ensure good take-up on services where they are built.
- Planning and administration activities as relevant to telecoms infrastructure in Orkney are in some cases restrictive.
- Openreach continues to seek ways in which best returns for investments in gigabit networks can be attained, and is supportive towards gigabit developments in Orkney and other regions.

1.6.2 Dialogue with Cloudnet

We spoke with Greg Whitton (CEO, Cloudnet IT Solutions Limited), and are grateful for the dialogue. Cloudnet is an altnet telco operator with interests in Orkney. The company offers internet connection services in the region using FWA and TVWS technologies. It is also interested in rolling out FTTP, subject to feasibility with an investment case. Key points from our dialogue are listed below:

- Planning for sites and wayleaves in Orkney can sometimes be challenging. Cloudnet is looking to acquire code powers from Ofcom, and would welcome OIC's support in rendering efficient site access and planning applications.
- Recent applications for microwave licences in the region from EE have caused a restriction for local operators seeking these (i.e. radio spectrum 'congestion').
- There was agreement that public intervention is needed to support the case for gigabit rollout in region, and the UK Government's Project Gigabit is seen as a key programme which should be leveraged.

We note that Project Gigabit comes with a number of prescribed terms and conditions as it stands, together with established public procurement and market engagement processes.

[22] See: https://www.openreach.com/fibre-broadband/where-when-building-ultrafast-full-fibre-broadband

2 Market requirements

We see principally two categories of demand for digital connectivity in the region, with: (i) B2C and B2B users, and (ii) public sector users, currently serviced by the SWAN public service network.

Whereas some in the industry continue to question the demand for gigabit access data services, the trend in data usage is clearly upwards, with annual growth levels of fixed access broadband data usage in the UK market sustained at around +30% CAGR[23]. Key traffic growth drivers include streamed video and gaming, with indirect drivers as high resolution smart TVs and devices, and shifts in social behaviour.

With fibre networks offering asset lives of decades once deployed, network designs must be able to provide good headroom for future demand. Another factor is user experience: with gigabit services, time taken for downloads is much faster than with legacy superfast connections, resulting in little or no buffering and satisfied users.

Gigabit capable networks are widely seen as an important investment for the future. If one assumes a demand level of 100Mbps as one reference point in today's market, with +30% CAGR over 10 years, the equivalent reference point after 10 years will be 1.3Gbps. Traffic is clearly growing, and future-proof networks, ideally with long asset lives, are seen as effective solutions.

2.1 B2C and B2B needs

With over 90% of Orkney's businesses employing fewer than 10 employees, the B2B sector is firmly driven by SME needs, which tend to be similar to B2C needs. In today's markets, larger businesses tend to require point to point FTTP links to support symmetric traffic links in excess of 1Gbps, with robust service level agreements and contracting.

As with the wider UK market, B2C and B2B demand in the region is driven by the need for gigabit connectivity to the public internet.

2.2 Public sector needs

The SWAN contract is well-established, having been awarded to Capita in 2014. It is intended to provide secure and resilient digital connectivity to public sector entities across Scotland including schools, hospitals, and council and government, with service integration and cost efficiencies via economies of scale[24]. SWAN provides a variety of VPN-like services for users, including connectivity, technical design, help-desk, reporting, security services, and billing.

SWAN is up and running in Orkney, and is largely reported to be meeting requirements in terms of security and resilience, although it is now lacking in terms of cost efficiency and access network data throughput capability (by virtue of data rate limitations in access networks – many of which in Orkney are via bespoke fixed wireless, running at around 20-30Mbps).

[23] https://www.ispreview.co.uk/index.php/2021/03/openreach-shows-increase-in-uk-data-traffic-over-past-year.html

[24] SWAN was developed following the McClelland report of 2011, focused on review of public sector ICT services. A key principle noted in the report was use of shared services and common infrastructure. However, ICT and networking has changed significantly in the last 10 years, with novel developments in neutral hosts and cloud native solutions, this has become the norm. Cost efficiency with such contracts can now therefore be debated.

It should be noted that the UK Government and others are progressively moving away from the public service network (PSN) approach (now somewhat dated), as it is deemed that the public internet is suitable for the vast majority of the work that the public sector does (with suitable security and other measures in place)[25].

As with the wider market, public sector users progressively are seeking access to gigabit connectivity. Access network capabilities are thus a limitation with the SWAN network.

The SWAN contract is due for renewal before March 2023[26].

Aggregated demand on the SWAN network in Orkney currently reaches up to around 650Mbps across dual 500Mbps links.

2.3 Coverage requirements

With virtually no gigabit access connectivity in place in Orkney, we assume a greenfield access build requirement (excluding Openreach planned FTTP build), addressing 13,042 * 65% premises. (We assume Openreach planned build at 35% of Orkney premises).

Population and dwellings are distributed across the main Electoral Ward areas as shown in Table 2.1.

Table 2.1: Orkney total population and dwellings by Electoral Ward areas[27]

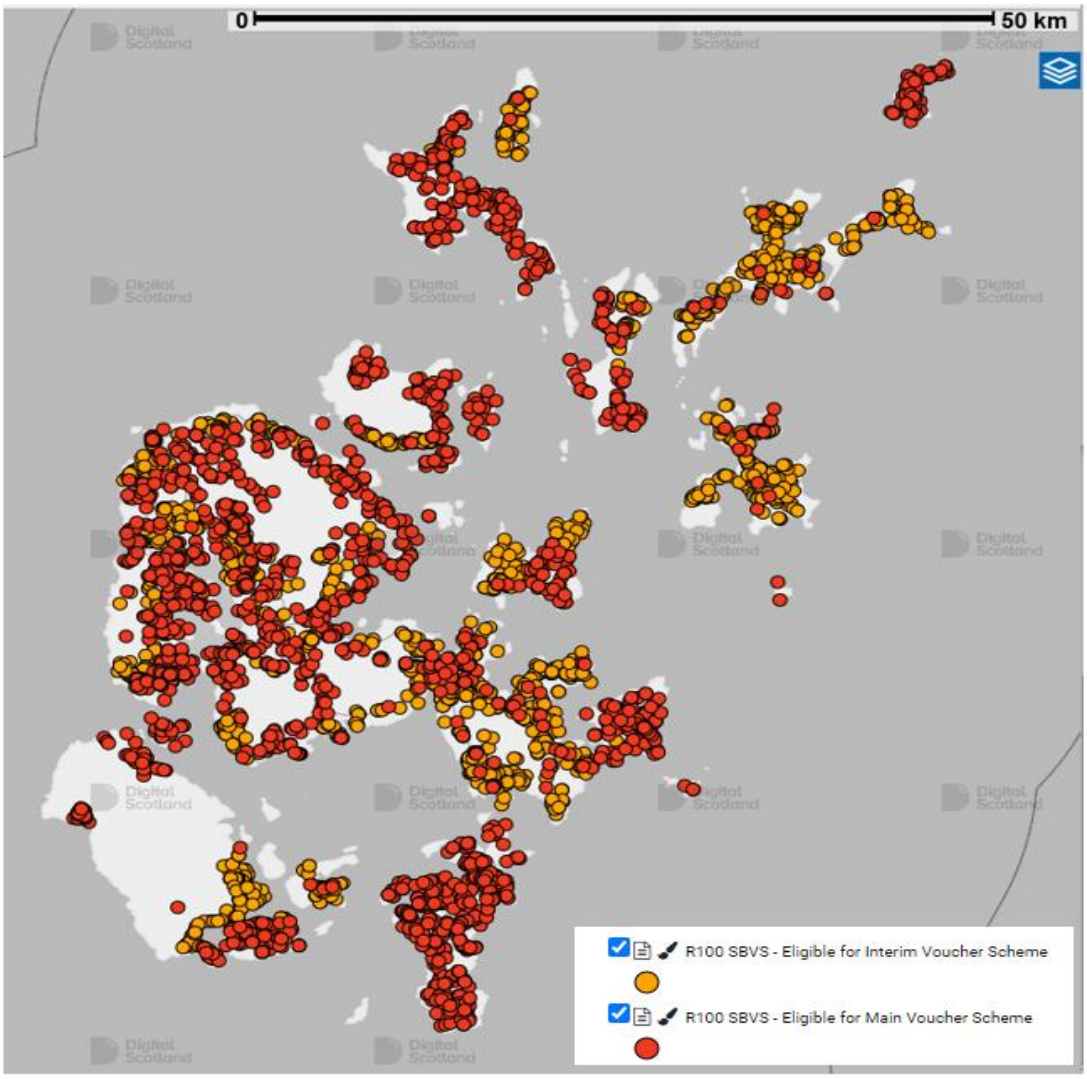
Orkney Electoral Ward area	Population (2020)	# dwellings (2020)	# dwellings (% total)
East Mainland, South Ronaldsay and Burray	4,040	1,884	16%
Kirkwall East	4,841	2,546	22%
Kirkwall West and Orphir	4,017	2,022	18%
North Isles	2,241	1,367	12%
Stromness and South Isles	2,625	1,463	13%
West Mainland	4,636	2,160	19%
Total	**22,400**	**11,442**	**100%**

The Orkney Islands cover a total land area of 990km^2. Maximum radial distance on land from Kirkwall is around 50km (North Ronaldsay).

Openreach planned FTTP build areas include Kirkwall and other parts of Orkney. Openreach is expected to build FTTP to some, but not all areas. Figure 2.1 shows premises eligible for SBVS vouchers.

[25] https://governmenttechnology.blog.gov.uk/2017/03/16/a-secure-future-for-psn-assurance/
[26] https://www.find-tender.service.gov.uk/Notice/019970-2021
[27] https://statistics.gov.scot/home

Figure 2.1: Premises eligible for SBVS vouchers[28,29]



2.4 Gigabit service take-up levels

Gigabit network investment cases are typically developed with take-up assumptions at around 50% after several years of operation. No firm data on this exists, as the UK market is still developing. For Orkney, we would expect take-up at these levels or higher, given the remoteness of the location, and the value to users of good internet connectivity (assuming retail prices in line with general UK FTTP prices; note that take-up tends to decline depending not only on price and broadband speed, but on level of improvement in broadband speed – less improvement contributes to less take-up).

[28] Data accessed by kind permission of The Scottish Government, Feb. 2022.

[29] The SBVS will provide two distinct levels of subsidy:

A 'one off' voucher worth up to £5,000 to help deliver a permanent broadband connection to those properties for which there is no roll-out of superfast broadband planned. Also known as a main voucher.

A 'one off' voucher worth up to £400 to help deliver an interim connection to those properties for which there is roll-out of superfast broadband planned from 2022 onwards. Applications for interim vouchers must be received by 31 March 2022. Properties in more difficult-to-reach locations may be eligible for an additional subsidy of £250. This is based on rurality and non-standard status of the installation. Also known as an interim voucher.

In some cases, rural addresses may be eligible to combine Scottish Government funding of up to £5,000 with funding from the UK Government's Gigabit Broadband Voucher Scheme (GBVS) which provides £1,500 for rural homes and £3,500 for rural businesses. If this is the case, chosen suppliers take this into account automatically and manage this.

3 Network architecture

We describe below our approach to network design to support the investment case. Further details are provided in Appendix A. Our focus is towards build-out of gigabit capable access networks and supporting FTTX and leased backhaul infrastructure. Both communities and public sector users are reliant on good quality access for all services. The existing SWAN network provides connectivity over IP access networks in the same way that internet service is provided for B2C and B2B users, albeit under different commercial and contracting terms (see section below on SWAN network).

We recommend a hybrid FTTX / FWA / FTTC approach for network development, balancing cost and performance. Whereas FTTP build-out is essentially 'the gold standard' for gigabit services, FTTP network deployment is both capital intensive and time consuming.

Modern gigabit capable FWA radio systems can provide more cost-effective solutions and rapid roll-out, especially in remote areas. These however are vulnerable to wind, corrosion and power outages.

FTTC networks are not gigabit capable, but may suffice as interim solutions where gigabit capable FWA cannot be deployed and end users have only very poor broadband services (e.g. <10Mbps). Evidence from the UK market shows that end users welcome improvements in broadband service, depending on current levels (e.g. access to ultrafast or superfast broadband is generally welcomed if service is only available at <10Mbps levels).

3.1 Broadband services

It is worth noting how broadband services are defined. Internet data is consumed in various ways, with various digital applications and services at the user level (e.g. PC email and file exchanges, two-way video calls, IPTV and music streaming, and B2B applications such as file servers or datacentres). The majority of internet traffic around the world today is driven by demand for video services.

Internet data is typically delivered in 'bursts', even when streaming services (e.g. Netflix) are consumed. This is due to the use of 'data buffering': memory in local applications which acts to 'smooth' the flow of data to the end user application. When internet connections are too slow, and buffers run to empty, this is seen by users as the familiar rotating dots symbol on TV or PC screens – showing that more data is required. In such cases, user services are disrupted until more data can be delivered.

Internet data rates can be measured principally in two ways: peak or average. Peak refers to the 'instantaneous' maximum 'burst' data rate possible with any given network design (i.e. 'line' speed), and average is the measured average data rate over some defined time period – with all the data rates ups and downs.

There is also the issue of network contention. To save cost, most networks are designed with some contention (or oversubscription ratio) built in. This is not unlike the practice of over-selling aircraft seats in the airline industry: at very busy times, some unlucky customers get 'bumped' (i.e. cannot access the service due to high demand). In network designs, contention is designed in with assumptions on network usage in practical situations: statistically, there is some probability associated with all connected customers in a local area wanting internet at the same time, at the same quality level, at the busiest time. Network design with well-engineered use of contention allows network backhaul to be implemented cost efficiently. We assume an access:backhaul contention level of max. circa 60:1 in our design, in line with typical industry practice. Contention levels can be scaled as networks evolve (at some cost of course).

With some ambiguity in the market with advertised data speeds, we refer to the gigabit technical specification adopted by BDUK in the Project Gigabit programme[30]:

- Gigabit capable line speeds (products) are defined as those with an access line speed (i.e. peak rate) of 1Gbps, minimum download speed at 330Mbps at busy hour, and minimum upload speed of 200Mbps (for 95% of the time). Link latency is also specified at 10ms or below (at the 95% level).

3.2 Network design principles

Cost structure and commercial viability for the network as a whole will depend on the network architecture.

Therefore, in line with market requirements for Orkney, we make a number of assumptions on technical design, costing, dimensioning, and location of key network elements such as local aggregation points, backhaul gateways, backhaul trunking, and IP backbone interconnect peering sites.

We assume that core network functions (e.g. BSS/OSS/NMS) will be housed in data centres, with connectivity via the public internet, and via cloud services.

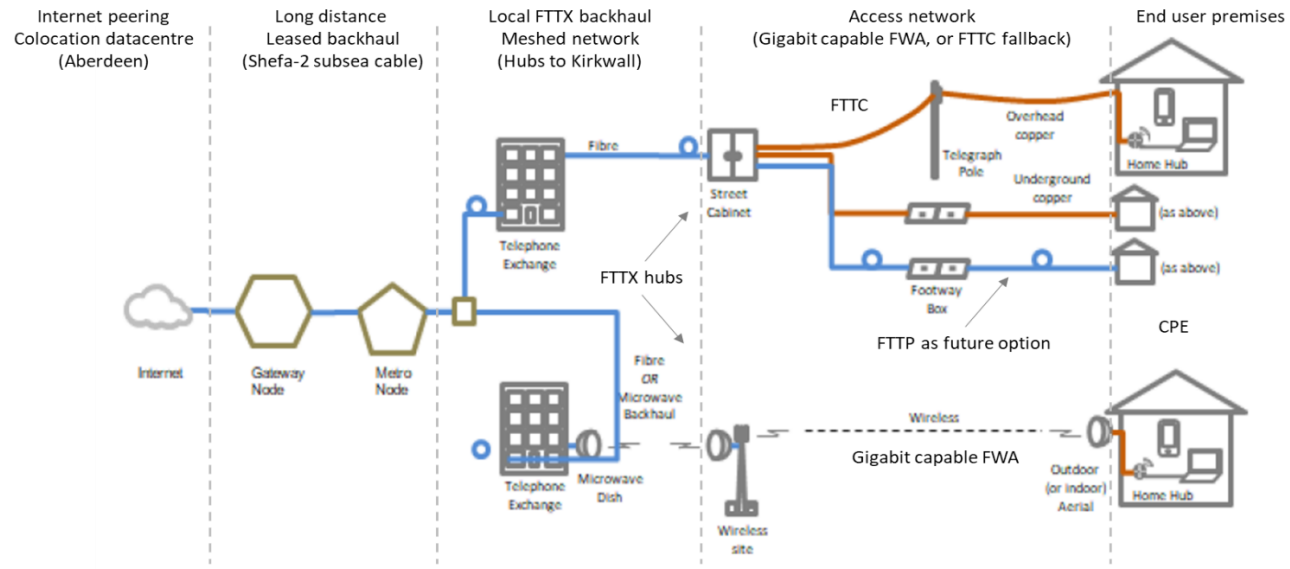
Overall, we assume that architecture will consist of the following key network domains, consistent with industry good practice:

- Access network: FWA sites providing gigabit capable connections to end users' premises;
- Local FTTX backhaul and aggregation: (often called local or main exchanges) where local connections are aggregated onto higher capacity network trunks;
- Long distance backhaul, via Shefa-2: network trunks connecting local aggregation sites with internet backbone connection sites;
- Internet hubs: major colocation datacentres (typically located in main cities across the UK), where local network providers are able to physically interconnect with the global internet (i.e. connect to other main network operators providing IP peering interconnections).

An illustration of network architecture with key elements is shown in Figure 3.1.

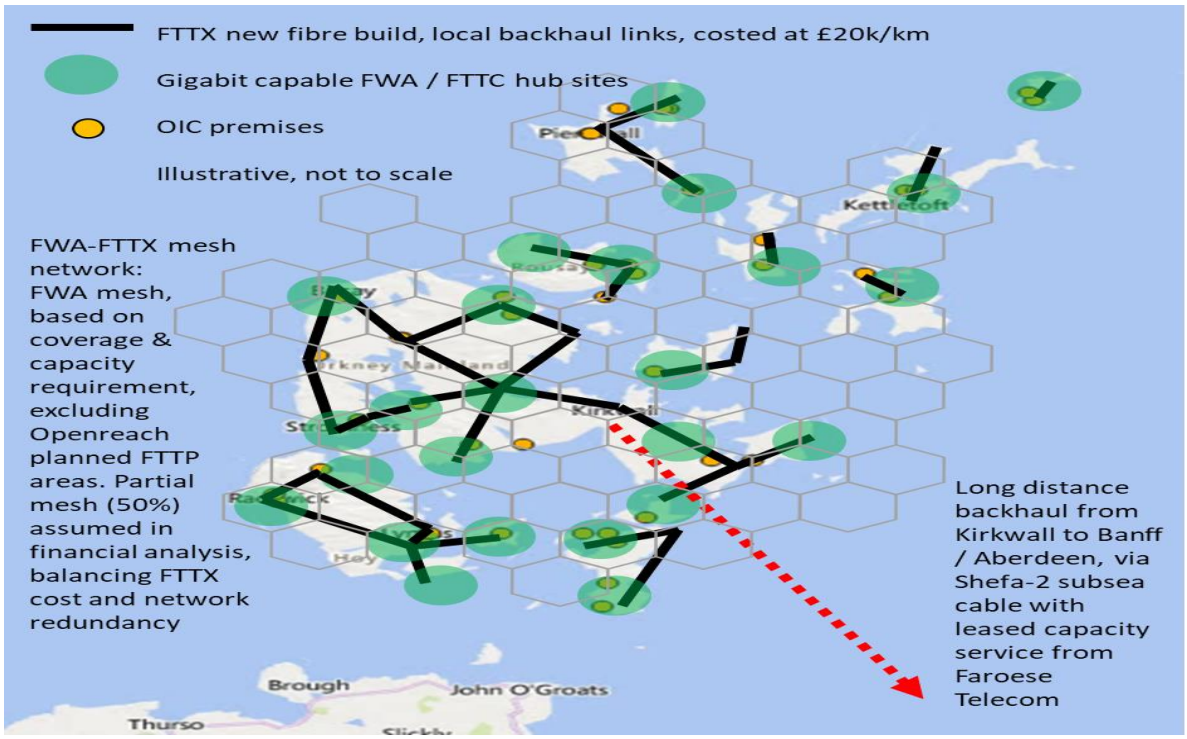
[30] BDUK Supplier Briefing: Project Gigabit Technical Specification, 2021. Note: whilst Project Gigabit funding comes with a number of requirements including design to support wholesale access, this is somewhat ambiguous and is being addressed progressively in the market.

Figure 3.1: End to end internet network architecture (illustrative)[31]



OIC premises locations are distributed across Orkney Islands, as shown in Figure 3.2. We assume that selected OIC premises are used as FTTX end points, with local backhaul meshed back to Kirkwall. Mean distance between OIC sites is estimated at 3km (for new FTTX fibre mesh). The figure shows illustrative FTTX network links, with cost dimensioning assumptions. In our model, number of hub sites is estimated at around 100, based on FWA capacity requirements.

Figure 3.2: OIC premises locations are distributed across Orkney Islands (illustrative)



[31] Source: BDUK, 2021. We assume gigabit FWA connections are deployed in the main, with new fibre links supporting FTTC connectivity in areas where FWA deployments are not feasible. Such an approach provides gigabit capable core network capability for the Orkney Islands, with FWA access links.

Key design and costing assumptions are laid out in Appendix A, with summaries on technical approach below.

Our network design assumptions are based on our own extensive experience in working with numerous FTTP and FWA operators in the UK market, and hence on practical situations.

3.3 Access network

Capital investment and operational cost levels at the access network level are driven by coverage and capacity requirements to premises, which in turn depend on backhaul point locations, link capacity levels, and distances to premises.

3.3.1 FTTP option

FTTP PON technology uses fibre splicing and splitting, enabling 'fan-out' of fibre at the local level. This can provide cost-efficiencies through reductions in trenching, ducting, and cabling costs. Typical splitter ratios at the access network level are 1:64.

Any greenfield FTTP new build programme incurs significant financial outlay driven by civil works costs for trenching, ducting, and cabling. Typical roll-out approaches in the UK market include FTTP build with clustering on premises and incremental build to reduce capital costs as much as possible.

Civil works costs can vary according to terrain types (typical trenching costs range from £10/km for soft earth to £100/m for hard rock, asphalt road or pavement).

With the significant requirement on civil works with FTTP roll-out, deployment can be both expensive and prolonged.

Therefore, we exclude new FTTP build in our assessment.

3.3.2 Gigabit capable FWA option (with interim FTTC solution as back-up)

Fixed wireless access (FWA) technology with point to multi-point connectivity (P2MP) provides an alternative to FTTP. Whilst FTTP technology provides good resilience, once deployed, with asset lives of 20-30 years, FWA can be much quicker to market and cost-efficient: no trenching is required at the access network level towards user premises.

Use of FWA is now well-established in the UK market, with many systems deployed using the 5.8GHz radio band, consistent with Ofcom regulations. Any implications on radio spectrum congestion will depend on usage and access levels at the local level. Radio access systems operating in this band, however, do require line of sight access between main radio towers and end user premises. FWA solutions of this type have typically supported user internet connections at superfast speeds (i.e. around 30Mbps).

A number of advanced software tools (e.g. WISDM[32], developed by Wireless Coverage Limited in the UK) are now available to support accurate and efficient development of FWA radio designs.

Recently, newer FWA radios have become commercially available supporting gigabit connectivity. These developments are based on 5G chipsets (instead of legacy 4G LTE and 802.11 chipsets), and are supported by recently introduced regulations from Ofcom, enabling FWA radio operation in the 3.8-4.2GHz licensed and

[32] See: https://www.wirelesscoverage.com/

60GHz licence exempt bands. The 26-28GHz licensed 5G band is also of interest for FWA operation, and Ofcom is expected to introduce licensing for outdoor use in the UK market during 2022.

Whereas FWA radios operating at the 26-28GHz and 60GHz bands can typically support radio links over just tens or hundreds of metres, 3.8-4.2GHz systems can support gigabit connections to around 10km.

Capital cost per connected premises (CPCP) for FWA solutions can be well under £1k, and significantly less than with FTTP access networks.

All this said, it is important to note that FWA and FTTP technologies are not directly comparable.

Radio systems can suffer from interference, asset lives will be lower than with full fibre, and per-site operational costs can be higher.

Therefore, we assume that in some cases, FWA access networks will be displaced by FTTC in the interim. In these cases, we assume similar costs for DSLAM and FTTX installation. FTTC will of course run over legacy copper circuits, with new fibre to the DSLAM, equivalent to new fibre to the FWA basestation site (FTTX).

3.3.3 Satellite option

Whilst the various so-called new LEO satellite initiatives (e.g. OneWeb, Starlink, Swarm) have attracted some attention of late, in our view these remain commercially unproven and unsuitable to deliver gigabit services at acceptable price and quality points.

As with many investors and independent observers, we continue to take the view that satellite-based communications systems are useful in limited niche situations including for use in: maritime and aeronautical cases, developing regions, areas prone to instability, and war zones.

3.3.4 Hybrid option

A hybrid access network, based on well thought out application of both FTTX and FWA technologies, can provide an effective solution, with most appropriate use of each technology according to regional market demands and conditions.

FWA technology is well-suited to more rural areas, where sparsely located premises can be linked to FWA radio sites.

FTTP technology is more effective in urban areas, where premises are clustered together and distances to main exchanges are limited.

In our hybrid option, we assume that FTTP build in the Kirkwall area and in some additional areas[33] is already committed by Openreach, and is therefore excluded from our assessment.

We assume FWA gigabit radio local access links using the 3.8-4.2GHz band to premises across all new build regions.

We assume that a fibre to the hub (FTTX) model is used, where hubs are either FTTC local cabinets, or FWA radio base sites (fibre mesh model to FWA basestation sites and FTTC nodes, to reduce FTTX build costs).

[33] See: Figure 2.1.

We recommend that OIC takes a key role in facilitating fibre to these hubs, with associated backhaul, essentially enabling the local access market to provide FWA and FTTC connections to end users premises. This approach also supports new FTTP build if required as a *future option*.

3.4 SWAN network

The Scottish SWAN network, using SD-WAN technology and a privately developed microwave link core, is used in Orkney to provide resilient and secure connections to public sector users including the hospital, GP surgeries, schools, and council offices.

The current SWAN solution is reported by OIC to be satisfactory in terms of technical performance, although access network connections, which are supported via public internet IP connections, are reported to be cost-inefficient – due to the connection charges on these which fall under the existing SWAN contract terms.

The SWAN contract is expected to be opened up for renewal shortly, with replacement expected by 2023.

Existing SWAN access services are limited by underlying access network data speed capabilities. Services up to 1Gbps are available (where gigabit links are available)[34]. Given that SWAN is deemed to offer satisfactory service (excepting with access network data speeds), our focus in the investment case is towards development of gigabit access network connectivity, with supporting backhaul. Access connectivity into SWAN is a somewhat separate commercial matter.

3.5 Local access aggregation

There are 23 Openreach local exchanges reported for Orkney, supporting LLU unbundling at the physical and bitstream level. As FTTP is rolled out, local exchanges are typically bypassed and replaced with gateway cabinets as a more cost-efficient option.

Therefore, we assume one main headend exchange located in Kirkwall, acting as a main gateway to access network facilities, and with direct connection to the backhaul network – which provides data conveyance to a major backbone internet colocation facility located on the Scottish mainland. Hence, we assume new fibre build from the headend exchange in Kirkwall to all FTTC / FWA sites (fibre cabling FTTX mesh model).

3.6 Backhaul

Gigabit access requires gigabit backhaul. Typically, backhaul nodes are implemented with scalable multiples of 10Gbps in full fibre networks.

We assume that internet backhaul is provided by third party suppliers on the open market, with most cost-efficient solutions adopted.

Backhaul is designed with one 10Gbps link supporting 2000 access users each with 5Mbps daily average busy traffic (typical contention ratio at around 66:1 on 330Mbps streamed products).

Multiples of 10Gbps links (e.g. Openreach EAD-10000 circuits) are then used to support backhaul for the whole of Orkney, with connectivity between the headend main exchange in Kirkwall and a major internet colocation backbone hub on the Scottish mainland (for IP traffic peering).

[34] See: https://www.scottishwan.com/media/1244/swan-catalogue-services-31.pdf

Overland backhaul to main colocation hubs proves prohibitively costly, as these hubs are located only in major cities. Using Openreach EAD circuits at open market rates, we estimate annual costs at around £250k pa (including 1+1 link resilience, and Openreach price supplements for FTTP access backhaul), plus around £100k connection charges.

Therefore, we recommend backhaul via the Shefa-2 subsea cable operated by Faroese Telecom. This provides connectivity from Orkney to Banff in Scotland. Limited overland backhaul connectivity in Scotland is then feasible to the IP peering facility located in Aberdeen.

3.7 Internet peering and colocation (backbone interconnect)

The UK as a whole is home to over 400 datacentres providing plenty of colocation (IP peering) opportunities. Many of these however are located in England, with nearly 200 in London alone.

In Scotland, the main datacentres are located in Glasgow, Edinburgh, and Aberdeen[35].

Aberdeen hosts 3 colocation datacentres.

We assume that interconnect equipment will be installed at the peering site; further details in Appendix A.

[35] Scottish Government advised us that the Scottish Futures Trust has developed plans for development of a number of new datacentres across Scotland. See: https://hostinscotland.com/storage/180/Shortlist-Site-Selection-Revision-1-September-2021.pdf; https://hostinscotland.com/storage/179/Longlist-Site-Selection-Revision-1-September-2021.pdf

4 Financial assessment

Our financial assessment is not exhaustive, and is intended to provide a level of accuracy as is typical in strategic investment cases for illustration of viability (as opposed to rigorous due diligence, supporting investment decisions).

Assumptions supporting our analysis are provided in Appendix A.

4.1 Funding assumptions

We spoke with a number of stakeholders during the course of our analysis, including Orkney Islands Council, BT, Openreach, Cloudnet IT Solutions Limited (Orkney altnet), and the Scottish Government. Many stated that further gap funding is best sought via the UK Government's Project Gigabit.

Whilst the R100 programme is providing some support for new submarine cables and some FTTP build in Orkney[36], the programme has been largely focused towards superfast build.

We agree that Project Gigabit provides a substantial pool of available funding (i.e. £5bn overall, of which £1.8bn is currently committed, for the UK as a whole), but caution that access to this comes with a number of prescribed technical and commercial requirements, and a rigid procurement process. In essence, 'intervention in the intervention' (i.e. some bespoke dialogue and agreement for Orkney gigabit funding) might be required to secure progress in this direction. We also note that Project Gigabit funding is mentioned alongside statements towards coverage for 85% of the UK's premises by 2025. Given that c. 80% of premises in the UK fall outside of the F20 (or rather F19) programme and are being built with private investments, this statement does not say so much. Around 20% of the UK's c. 30m premises fall in rural areas.

Overall, we would expect that a mix of public and private funding will be used to deploy gigabit capable connectivity across Orkney. Given the difficulty of investment cases in rural areas, we would expect that commercial investors would provide a relatively small proportion of funding (e.g. 10%) if any, with overall funding provided by government gap funding.

In our financial assessment, we examine the level of total funding required for gigabit capable build out across Orkney, excluding Openreach planned build (assumed at 35% of premises). Our assessment includes new build and operations for access networks, FTTX local backhaul, operations and peering, and long distance backhaul to Aberdeen (required for IP peering). Total funding could come from vouchers and project gap funding.

Below, we set out an investment case, with aggregated total costs supporting new gigabit network deployment with full coverage (i.e. to 65% of Orkney premises, excluding already committed Openreach build assumed at 35% of all Orkney Islands premises), and revenues based on retail pricing[37]. This is provided to indicate the sustainability of any investment: there is little point in funding build-out with significant capital from any sources if long term operational costs cannot be supported by a healthy stream of ongoing revenues.

The cashflow analysis also provides an indication of the time for any build project to break even.

[36] See: https://www.gov.scot/news/superfast-broadband-subsea-work-to-start/
[37] We assume modest retail margins over wholesale prices, given the remoteness of the location.

4.2 Cashflow analysis

Results from our analysis are provided below in Figure 4.1 (base case, 65% prems FWA / FTTC build outside Kirkwall, FTTX to main exchange, meshed).

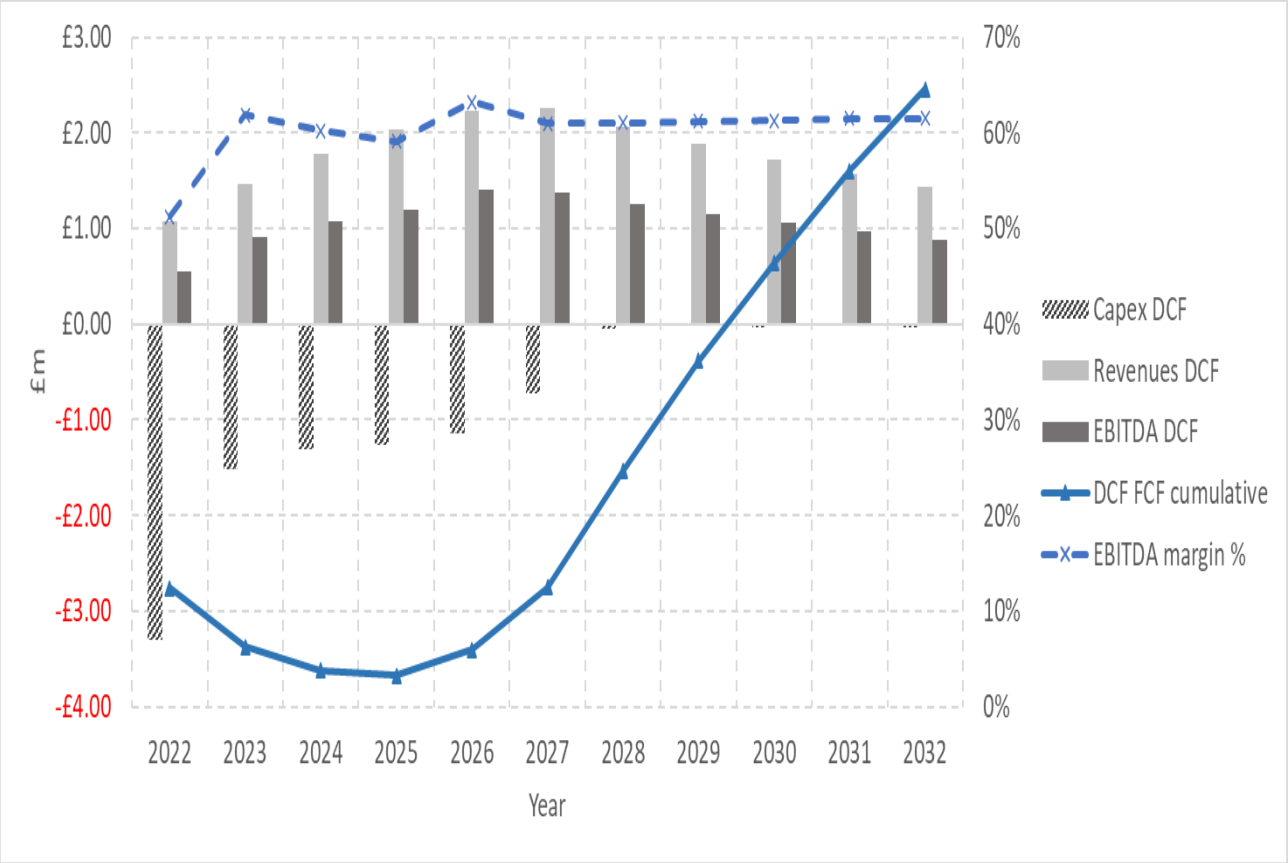
We assume no subsidies on CPE equipment throughout (i.e. customer pays).

Mesh 'density' is set in our model at 50%, meaning that a fully meshed local FTTX backhaul network is not implemented.

We define full meshing where each FWA/FTTC hub site would be connected to four others, as in a grid mesh. With fewer hub-hub connections, partial meshing arises. In the lower limit, the mesh would become a daisy chain network.

We recommend that some meshing is retained, to ensure resilience, and balanced capital outlay.

Figure 4.1: Free cashflow analysis (connectivity to all premises, excluding already committed build)



In the base case, break-even is attained at around year 8, and peak funding sits at £3.67m.

EV/EBITDA at year 10 sits at around 5.8, in line with telecoms industry benchmarks.

5 Concluding remarks

5.1 Key observations

- For the base case as modelled (65% FWA coverage, % total Orkney premises), cost per connected premises (CPCP) (blended) sits at £1.1k.
  - We estimate total capex at around £11.4m;
  - Capital costs could be reduced with a lower level of meshing on the FTTX network, or with use of point to point microwave links to provide link resilience (i.e. failover).
  - Peak funding is £3.67m (DCF, at year 4);
  - EBITDA margin is positive and healthy at around 60%, in line with efficient altnet operators, indicating that a sustainable wholesale business is feasible (subject to customer take-up, capital funding, and overall cashflow feasibility, as above).
- Roll-out of full fibre for all remainder 8.4k premises on Orkney (100% FTTP, 0% FWA) is likely to be cost prohibitive. We estimate total capex for the remainder 65% FTTP roll-out in excess of £50m (i.e. average CPCP >£5k).
- FTTP network costs are driven significantly by greenfield trenching and cabling costs. Once deployed however, FTTP networks are able to be upgraded with new headend equipment to accommodate years of traffic growth; FTTP cables will typically sustain asset lives of 20-30 years or more.
- FWA networks are more sensitive to traffic growth demands. Our assessment is dimensioned at just over 60 premises per FWA site, in line with typical industry practices and the Project Gigabit technical specification (1Gbps peak, 330Mbps streaming), i.e. contention per site at 66:1. If lower contention levels are required, additional capex investment for the FWA network would be required over time.

5.2 Roadmap for implementation

FTTP and FWA networks are typically managed with phased build-out programmes. This ensures focus on particular areas, which may accord with communications plans and resource management.

Network build-out rates vary considerably according to technology types used and area density and terrain types. FWA technology will typically support faster network roll-outs, and rural areas will tend to require longer build programmes than urban centres. For a hybrid programme with phased area build, in a predominantly rural area, such as Orkney, we would estimate a build-out programme of around 4-5 years, based on typical industry programme rates (on passed and connected premises), and requirements for wayleaves and access rights.

Openreach's current plans[38] indicate that FTTP build for Kirkwall is planned from 2021 to 2026.

Prior to any build-out programme, capital will need to be raised, designs done, suppliers engaged, and any public gap funding secured via due process.

[38] See: https://www.openreach.com/fibre-broadband/where-when-building-ultrafast-full-fibre-broadband

5.3 Recommendations

- We note that the SWAN contract is being tendered for renewal (covering the whole of Scotland). Given that the SWAN network is currently reported to be meeting technical requirements, we are not recommending any associated actions. With SWAN access dependent on quality of local access network connectivity, we recommend that focus is maintained on improving local access network quality, whilst commercial matters with SWAN (including access circuit pricing and overall contracting to requirements) are dealt with separately.

- Whereas the current SWAN network includes a purpose built core, costs associated with leverage (or rebuilding) of this will be lower than for new build at the access network level. As public services networks are progressively moving towards use of the public internet (with security and quality requirements implemented via SD-WAN technology), we recommend that the SWAN core is replaced in due course with a fibre based core (given reported problems with microwave links due to weather conditions). If the new SWAN contract is based on use of the public internet, then a common fibre core would be required and would afford some cost synergies. We recommend that core and access network developments are considered carefully alongside any developments in SWAN to maximise synergies.

- Given that much of Orkney is very rural, we recommend a hybrid FTTX/FWA/FTTC access network approach. This approach will support timely roll-out to premises, and efficient use of capital investment.

- Take-up objectives should be supported with an awareness campaign, led by OIC, targeted at consumers, showing the social and commercial benefits of gigabit connectivity.

- Gap funding is presently available via the Scottish R100 programme and UK Government's Project Gigabit, as well as with gigabit vouchers (supplier- and therefore market- led). All of these initiatives require due process to be followed: procurement bids must be assembled and won. That said, in our dialogue with both the Scottish Government and UK DCMS / BDUK, dialogue with both public and private sector entities is not only welcomed, but actively encouraged. Therefore, we recommend that OIC ensures that proactive dialogue is leveraged to promote requirements and access to funding for Orkney.

- Backhaul costs (from Orkney to main internet peering and colocation sites) represent a significant element in the investment case, and need to be optimised. We recommend that dialogue with Openreach is pursued to seek more efficient pricing on EAD circuits (subject to regulatory limitations). The Shefa-2 long distance submarine cable is likely to present a more attractive backhaul option than with overland circuits. Therefore, pricing from Faroese Telecoms for Shefa-2 submarine cable based backhaul is used in our assessment.

- We heard from two stakeholders that OIC's own planning and administrative processes are restrictive in regard to development of gigabit connectivity for the region. We recommend that this is looked into as a priority.

- Finally, our P&L assessment indicates that a viable telco operation is feasible for the whole of Orkney, with key metrics in line with modern efficient telcos making use of novel technologies and commercial models (e.g. cloud-native core networks), subject to take-up levels which we assume as trending to 100% towards the five year point and beyond (rationale: single wholesale network for the region, limited infrastructure competition).

Our focus in this work has been towards development of an investment case supporting 100% gigabit capable rollout for Orkney.

Glossary of terms

A non-exhaustive glossary of terms used is provided below.

Acronym / term	Description
Access network	Part of a telecoms broadband internet network that connects end user premises to local hubs or exchanges
B2B	Business to business (market segment)
B2C	Business to consumer (market segment)
Backhaul network	Part of a telecoms broadband internet network that connects local hubs or exchanges to main internet backbone peering sites (typically located at major cities)
Capex	Capital expenditure
CPE	Customer premises equipment
DCF	Discounted cash flow
DSLAM	Digital subscriber line access multiplexer (used to connect FTTX fibre to digital copper lines)
EBITDA	Earnings before interest, taxes, depreciation, and amortisation
EV	Enterprise value
FCF	Free cash flow
FTTC	Fibre to the cabinet (supporting xDSL services over copper line to premises from hubs)
FTTP	Fibre to the premises (full fibre)
FTTX	Fibre to the local hub (supporting FWA or FTTC from the hub to the premises)
FWA	Fixed wireless access (wireless broadband last mile)
GBVS	Gigabit Broadband Voucher Scheme implemented by UK Government
Gigabit capable	A network capable of supporting gigabit line speeds, in line with BDUK technical specifications
ISP	Internet service provider
Mesh	A network architecture where nodes are connected with 1+N redundancy to provide failover link resilience. Greater redundancy provider greater network resilience at greater capital cost.
Opex	Operating expenditure
P&L	Profit and loss
SBVS	Scottish Broadband Voucher Scheme implemented by Scottish Government
SD-WAN	Software defined WAN
SME	Small to medium enterprise (market segment)
SWAN	Scottish Wide Area Network (network supporting public services)
WAN	Wide area network

About the authors

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Ian is a Director and an established independent consultant in the telecoms/TMT/digital sectors, bringing over 30 years of experience gained through global consulting and industry. He has worked across the full industry lifecycle from start-ups and investor funding, through strategic planning, to hands-on engineering and programme delivery.

He has supported clients extensively in the UK and internationally, in strategy, policy, due diligence, and programme delivery projects on FTTP, 5G, and FWA gigabit radio networks.

His consulting approach is with high impact projects that make a real difference, combining insight, pragmatism, practical experience, and hands-on delivery, yielding optimal value for clients.

Formerly with PwC TMT Strategy London, Nokia, Oracle, and Bell Labs, his experience spans both technology and commercial domains and includes: consulting sales and business development, management of the professional services firm, strategy development and business planning, policy and regulation, consultation responses, digital strategies, regulatory and commercial cost modelling, radio spectrum planning and valuation, investment planning, M&A advisory, due diligence, CTO/CIO advisory, performance and process improvement, procurement and bid development, network and IT systems transformation, and large scale technology programme management. His client base includes national and local governments, industry bodies, regulators, telcos, ISPs, enterprises, vendors, investors and law firms.

During the early part of his career, he worked in new systems and was awarded the Bell Labs President's Prize for R&D and product development at Bell Labs NJ USA. Ian holds PhD and BSc (1st Class Hons, IET Prize) degrees in Telecommunications and Electronic Engineering, plus PgD in Management and Finance, UK Chartered Engineer, Fellow IET, and VC of the techUK Communications Infrastructure Council.

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Appendix A Key assumptions

Our key assumptions supporting our financial assessment are provided below.

We assume that FTTP is committed build by Openreach in some areas, with new hybrid FTTX/FWA/FTTC networks deployed in all other Orkney areas. In the longer term, further FTTP could be built out progressively.

- FWA / FTTC access network (Orkney areas outside Openreach planned build):
  - Leading edge gigabit capable radio (5G chipset based FWA, operating in the 3.8-4.2GHz shared access bands) is employed (with at least 2x2 MIMO), with technical design to gigabit capable data speeds commensurate with UK Government's Project Gigabit Technical Specification.
  - FTTC (non- gigabit capable) as *fallback option* in cases where gigabit capable FWA is not viable.
  - Premises outside Kirkwall Ward areas: 8,474.
  - We assume 66 premises maximum per FWA radio site supporting 1Gbps peak, 330Mbps burst average streaming, 5Mbps daily average traffic per premises. Range per site = 2.5km; maximum area coverage per radio site = 20km^2.
  - Total site count for whole of Orkney, based on coverage = 990km^2 / 20 = 50 FWA radio sites.
  - Taking capacity into account, total site count = 8474/66 = c. 130 FWA radio sites.
  - Cost per FWA radio site, including mast, FWA radio equipment and power cabling: £15k.
  - Cost per DSLAM site, as fallback option: £15k.
  - FWA radio site / FTTC site local FTTX backhaul: full fibre from Kirkwall main exchange to each radio site: average fibre cable run at 3km (meshed site to site). FWA local fibre backhaul cost = £20k/km. This cost could be reduced if P2P microwave links were used for local backhaul.
  - We assume partial meshing on the FTTX network (at 50%), i.e. every FWA/FTTC site is connected by 2 FTTX links. This balances capital outlay with resilience.
  - CPE and premises installation costs (rooftop antenna, modified router, and technical install at premises): capital cost of £250 per connection total, including radio planning cost. CPE costs borne by customers, not capitalised.
- Core network BSS / OSS and cloud services + data centre costs:
  - Local data centre / cloud opex: £10k pa.
- Backhaul and trunking:
  - Local connectivity from access networks is aggregated at the main exchange level.

  - There are 23 Openreach local exchanges[39] across Orkney, supporting LLU unbundling at the physical and bitstream level. As FTTP is rolled out, local exchanges are typically bypassed and replaced with gateway cabinets as a more cost-efficient option. Therefore, we assume one main headend exchange located in Kirkwall (with backhaul to main internet backbone colocation hubs).

  - Backhaul from Orkney overland to main Scottish internet colocation sites proves prohibitively expensive. Therefore, we assume backhaul (from Orkney to Banff to Aberdeen) is provided via a combination of overland and subsea leased circuits:

    - We assume 10Gbps leased line per link, supporting 2000 users each with 5Mbps daily average busy traffic (typical contention ratio at around 60:1).

    - Overland backhaul provided using leased bitstream services with pricing based on Openreach EAD-10000[40,41] (10Gbps) products. Annual cost per 40km link at £12k. Two legs required on distance, Banff to Aberdeen is 60km, with 1+1 redundancy for resilience. Total overland backhaul cost: £48k pa per 2000 premises, 13,042 premises on Orkney, hence 7 * £48k = £336k pa.

    - Subsea backhaul is available with the Shefa-2 subsea cable (operated by Faroese Telecom) which runs directly from Orkney (Ayre of Cara) to the Scottish mainland (Banff, around 60km from Aberdeen). Total subsea backhaul cost: £71k pa per 10Gbps bitstream circuit[42].

  - We assume that internet IP peering takes place at a colocation data centre (global internet connection) located in Aberdeen[43].

    - Colocation data centre IP peering interconnect site costs: £12k pa;

- Contingency costs:

  - We assume +10% contingency costs across all items.

[39] Detailed information on Openreach exchanges is not in the public domain. We have used available public sources. See: https://www.ofcom.org.uk/__data/assets/pdf_file/0021/190029/local-exchanges-data.pdf

[40] https://www.openreach.co.uk/cpportal/products/pricing

[41] EAD: Openreach Ethernet Access Direct products provide point to point bitstream data connectivity between sites (i.e. access network gateways to colocation datacentres for IP backbone connectivity). See: https://www.openreach.co.uk/cpportal/products/ethernet/ethernet-access-direct

[42] See: https://www.lightwaveonline.com/business/market-research/article/16654174/myriad-factors-conspire-to-lower-submarine-bandwidth-prices; https://www2.telegeography.com/hubfs/2018/Presentations/APRICOT-2018-Submarine-Cable-and-Capacity-Pricing-Trends-in-Asia-Pacific.pdf. Shefa-2 cable pricing provided by Faroese Telecom.

[43] The UK has a number of major colocation data centres where IP peering takes place between major telecoms carriers. Backhaul costs from access networks may be distance dependent, depending on datacentre locations and commercial terms at the carrier to carrier level. Major data centres in Scotland are located in Glasgow, Edinburgh, and Aberdeen. See: https://discover.cloudscene.com/market/data-centers-in-united-kingdom/all

