THE ROYAL SOCIETY OF EDINBURGH

Digital Scotland

an interim report for consultation

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To whom it may concern:

Digital Scotland: an interim report for consultation

In 2009, the UK Government published its Digital Britain report, and set out an ambition, ***"to secure the UK's position as one of the world's leading digital knowledge economies."***

Building on this, the Royal Society of Edinburgh set up a working group to take a broader view of the ways in which technological change could be stimulated and exploited for economic and social benefit, and to explore these within the particular economic, social and geographic context of Scotland. Its intention is to stimulate debate, to identify priorities, to suggest the roles that governmental and nongovernmental actors might play in exploiting the digital world, and to recommend some strategic priorities for Scotland.

The first draft of a report is enclosed, which concentrates on a number of vital issues that need urgently to be addressed in Scotland and the rest of the UK to ensure that the coverage, speed and use of our digital infrastructure will allow us to grasp the opportunties of the new digital world. We must ensure that our targets match those of at least most of our competitors — to do less is to be left behind.

Our report concentrates on four key areas — users, infrastructure, content and benchmarks — and develops four major recommendations:

- to remove fiscal and regulatory obstacles to universal connectivity,
- to enable competition and cooperation,
- to stimulate development and uptake, and
- to ensure universal access and digital inclusion

This is work in progress. We intend that our final report will evolve considerably, particularly in developing the key challenges and in elaborating recommendations that will address them. We can best do this if we receive comments and suggestions from a wide range of stakeholders. We therefore ask you to consider this draft and suggest ways in which it should be amended by identifing opportunities and obstacles, and suggesting ways that they might be addressed. This will produce a more robust long-term strategy.

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Please address comments to:

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Executive Summary

Digital society

Digital technologies are changing the ways we communicate and interact, socially and commercially, and thus changing the fabric of society. The digital society extends advantages — new efficiencies and new goods – spread across the economy and society.

Scotland needs a Digital Strategy to keep pace with progress in a rapidly changing world. This will enable local enterprises to participate in the global digital economy, include local communities in the global digital society, and allow Scotland to exploit new opportunities — afforded by current and future technologies — for innovation in government, manufacture, culture, education, health and commerce.

The competitive position of Scotland's information infrastructure will determine our place in the global digital society. Just as transport infrastructure was a key to widening domestic markets in the 19th Century, so our digital infrastructure will determine our participation in global markets in the 21st Century. It will be as important as our physical cultural infrastructure in establishing and communicating our cultural identity. This infrastructure is the connective tissue of the digital society. It supports an information eco-system that is changing the way we live.

Scotland rightly has national strategies for transport and culture. A Digital Scotland strategy should address Scotland's inclusion in the digital society.

Continuing change

Scotland took an early lead in ensuring universal access to first generation broadband, because it was recognised that the benefits of broadband adoption accrue not just to individual consumers, but to other broadband users and society as a whole. This may suggest that internet access in Scotland is a solved issue.

It is not: just as computer performance has increased exponentially for over 30 years (Moore's Law), so median broadband speeds are expected to follow Neilsen's Law: they will double every 20 months, increasing 64-fold over the next decade. Scotland should ensure universal access to an evolving digital infrastructure that keeps pace with these global developments.

Why a strategy is needed

Initial development and wide-scale roll-out of digital communications technologies was largely driven by consumer markets in entertainment and gaming. Other uses of the internet, including surfing, email, banking and shopping, now dominate.

Consumer demand will not lead to optimal provision because the benefits of broadband adoption are not all returned to the broadband customer, nor to the supplier. These benefits are widely distributed, across society. In particular, social benefits — for education, health, commerce, social inclusion, and equality of opportunity — are external to the broadband supplier-consumer relationship. Economists call them "positive externalities".

Social benefits provide no direct incentive for telecoms companies with limited capital budgets to extend access, nor do they feed through to proportionate increases in consumer demand. Providers will always deploy digital infrastructure selectively, prioritising affluent, densely-populated regions, where lower costs generate higher revenues. Consumer-driven provision therefore leaves those who already suffer social exclusion without access .

Where the market fails to provide, for reasons of distance or deprivation, intervention will be required to ensure access to the digital society. Universal access would maximise the social benefits: it would provide equality of opportunity, equalise the distribution of economic activity, and increase social cohesion.

Connected open networks

The internet is a network of networks. It does not rely on central control or coordinating facilities. Any network that adheres to the internet protocol can connect to the global network by negotiating a "backhaul" connection to one or more already connected networks[1]. Some networks merely carry traffic from one network to another, facilitating global connectivity; some are the internal networks of organisations and corporations; others exist to connect individual subscribers to the global internet. Local access networks connect to each other, and to wide area networks that provide backhaul, in a digital symbiosis.

In a country such as Scotland, with diverse human and physical geography, the local access networks connecting local communities will use a variety of electrical, optical and wireless technologies. Communities can aggregate demand to achieve communal benefits, so some communities will be motivated to develop their own local access networks, even where individual consumer demand does not justify market investment.

There are opportunities for local innovation and investment to develop and maintain novel architectures for local access networks. These require access to wide-area networks that provide high-speed backhaul connections. Although existing providers may view community networks as unwelcome competition, open access to backhaul would stimulate competition, innovation, and broadband penetration.

Placing a backhaul connection within reach of every community in Scotland, and ensuring an open market in backhaul provision, would extend the market-led roll-out of mobile and fixed broadband, and enable local innovation and entrepreneurship to develop local access networks where national providers choose not to invest.

Digital inclusion

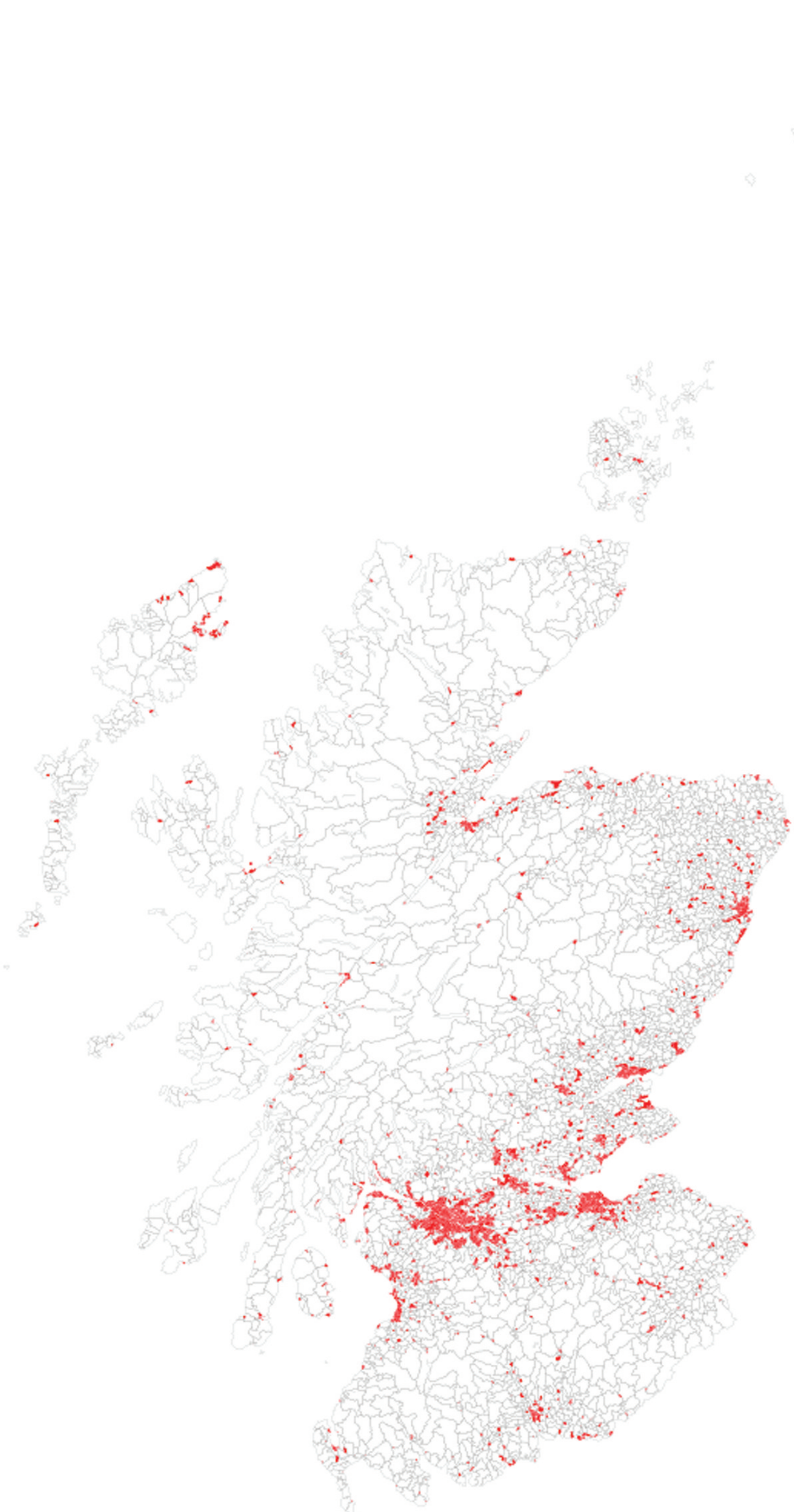
Until every home is connected, public provision of internet access in supportive environments, such as libraries, waiting rooms, and community centres, is required to ensure universal access. Once access is achieved, digital training and support can be naturally integrated into existing educational and social support systems.

Recommendations

1. Remove fiscal, regulatory and competitive obstacles to the establishment of interconnected fiber networks that provide backhaul within reach of every community.
2. Enable competition, in the wholesale and retail provision of connectivity through the backbone to the global internet, to stimulate market provision of mobile and fixed access to every community.
3. Stimulate development and uptake of digital technologies through open-access publication of public data and public procurement of standards-based, open source systems.
4. Provide public access, skills training, and support networks to ensure universal digital inclusion.

We have not undertaken rigorous impact analyses for our proposals. However, the first three are cost-neutral interventions that would significantly change market pressures, by stimulating backbone provision and reducing the marginal costs of local access. This would increase private sector investment in both core and local access networks and reduce the costs of the public sector interventions required in any persistent areas of market failure.

1 "Backhaul" is the connection from the local network to the rest of the world.



Scotland Census 2001

Census output areas with population density greater than 50 inhabitants per km² shown in red; elsewhere the population is sparser.

1 A changing world

The last two decades have seen a global socio-economic transformation of historical proportions. New digital technologies have wrought an immense increase in global economic interaction, and been vital agents in the shift of the global economy from one rooted in land, labour and capital towards one shaped by information and knowledge. New markets have disrupted pre-existing forms, and the potential for public benefit in health, education, leisure and many other areas of human acitivity is being explored and realised. Young people have led in creating new modes of social and political intercourse unanticipated by those who developed and introduced the underlying technologies.

This digital revolution has only just begun. The pace of change will accelerate rather than falter. Information technology is the connective tissue of the modern society. Hardware and software support the metabolism of a complex, evolving socio-technological eco-system that is an integral part of the way we live, and that will increasingly underpin our futures. The accelerating pace of change presents major challenges.

How can Scotland keep pace with global developments? How does government identify and create a framework of regulation, incentive and investment that will enable the development of a sustainable basic infrastructure and private sector ecosystem that will build creatively upon it? Can we create the conditions for disruptive innovation? Can we break down the damaging digital divide and use these technologies to strengthen all our communities and extend the reach of education and healthcare?

2 The need for action

These issues are central to Scotland's future. Other countries are already implementing changes that will propel them into the future. Scotland needs to develop both the profound thinking required to develop a strategy, and the means, in difficult economic circumstances, to take some of the decisive steps that will be needed to ensure our progress.

Many excellent initiatives are under way in Scotland, particularly in health and education. However, without decisive action, their reach will be limited by lack of infrastructure where it is most needed. Only a decisive strategic frame can produce the infrastructure that will enable digital inclusion — equality of opportunity in the digital society.

Failure to rise to this challenge will have the consequence of serious social, cultural and economic impoverishment compared to many other countries. Scotland excels in the whole realm of informatics, including information technology. However, the many issues to be addressed are complex, and the pace of innovation and change is rapid. A race is being run. Scotland will need to draw expertise together from sometimes competing interests, who must now collaborate to compete on a wider stage.

3 Users and benefits

Good telecommunications access has evolved from a luxury into a necessity. The internet is evolving from an information delivery technology to become a primary vehicle for social and economic interaction.

This already provides new opportunities. For example, in healthcare,

> Patients in Caithness General Hospital receiving kidney dialysis can now have reviews carried out remotely with their consultant at Raigmore Hospital, Inverness, cutting out a 200 mile round trip. A similar teledialysis link has been used in the far north of Norway since 2000, to connect a main renal unit with three outlying clinics.[2]

2 http://news.bbc.co.uk/1/hi/scotland/highlands_and_islands/8634562.stm

In education, the Pathfinder project has brought broadband to every school in Scotland — but in this example the impact is currently limited by lack of connections to children's homes:

> Mallaig High School makes extensive use of GLOW, Scotland's national intranet for education. Pupils from the Small Isles board weekly. In the winter the sea crossing is often impossible, and weeks of school time are lost due to bad weather. The bandwidth currently available on the Small Isles does not support GLOW. A high-speed internet connection would allow storm-bound pupils to access GLOW from their homes, and to interact with their classes via telepresence.

A digital society, where many aspects of life are conducted online, supports more efficient businesses and can deliver better healthcare, education and social services at reduced cost. Those unable to access these services suffer exclusion from the benefits of the digital society. This can create new inequalities and exacerbate existing social and economic divides.

The internet is an efficient transport network for digital goods, already substituting for physical delivery of mail, music, videos, newspapers, books, magazines and photographs. It is an efficient communications network, substituting for the fax and telephone, and also providing video calls and conferencing. It makes reference libraries available, anytime, and almost anywhere. Together with its associated technologies for collecting, storing, analysing, processing and visualising data and information, it brings a host of new goods and labour-saving devices into the hands of every man, woman, and child.

Just as an electricity supply is required to benefit from many 20th Century innovations, a broadband connection gives access to a range of new digital goods and services that we will come to see as essential. In the 21st Century, information networks will become as critical to social inclusion and economic prosperity as transport and electricity networks have been in the 20th — the telephone, like the telegraph before it, will become a footnote in the history of telecommunication.

3.1 Continuing change

We must prepare for a period of change. Predictable advances in communications technology will lead to further disruptive changes in social and commercial services. Technological advances will be exploited, globally, to replace broadcast media by on-demand access and to introduce new levels of remote telepresence and interaction. Applications will increasingly depend on symmetrical connections that feature high data rates with low latency, both upstream and downstream.

According to the EU Directive on universal service obligations and users' rights relating to electronic communications networks and services, provision of access includes sending and receiving data at rates sufficient to permit functional internet access, taking into account prevailing technologies used by the majority of subscribers and technological feasibility. We believe that next-generation internet access will soon fall within this definition.

As the usage of broadband interaction increases, prevailing technologies will follow Neilsen's Law. A dynamic definition of universal service is implied. The minimum connection rate for universal access must track advances in the information society to ensure continuing digital inclusion.[3]

The most important advances will probably be those we cannot predict. We can however already foresee that these technological advances will bring new ways of life. We briefly consider some of the ways this will change society.

3 See the *Infrastructure* section for details.

3.2 *Economy*

Businesses in connected communities can be more efficient and can access global markets, making their local economies more productive. Digital infrastructure can improve quality of life, helping to attract residents and sustain local communities. Conversely, employers and young people will move away from communities that cannot offer digital inclusion.

All industries are being fundamentally changed by new information technologies. Consider, for example the International Standard Industrial Classification[4]:

- Agriculture, hunting, and forestry;
- Fishing;
- Mining and quarrying;
- Manufacturing;
- Electricity, gas and water supply;
- Construction;
- Wholesale and retail trade; repairs;
- Hotels and restaurants;
- Transport, storage and communications;
- Financial intermediaries.
- Real estate, renting and business activities;
- Public administration and defence; social security;
- Education;
- Health and social work;
- Other community, social and personal service activities;
- Private households with employed persons;
- Extra-territorial organisations and bodies.

Many intrinsically require a community with mobile as well as fixed internet access to derive maximal benefit.

In addition, the IT sector itself brings productivity. While only 6% of the UK population works in the IT-related sector, these jobs produce 10% of the GDP (the remaining 94% of workplaces produces the rest, 90%). This means that each job in the IT sector produces, on average, 74% more value than other "traditional" sectors. Increasing the use of digital technologies will have the added benefit of stimulating growth in this sector.

The importance of information technology in productivity was pointed out both in the old "Lisbon Strategy"[5] and in the new EU 2020 strategy[6]. Both strategies recognise "innovation as the motor for economic change".

Advances in communications infrastructure reduce transaction costs and provide access to global markets. These come hand-in-hand with advances in data collection and analysis. Improved decision making reduces the reaction times of businesses responding to threats and opportunities. Modelling and simulation are used to optimise designs and reduce risks.

4 http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=2

5 http://en.wikipedia.org/wiki/Lisbon_Strategy

6 http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

Today, tools for analysis, modelling and simulation are normally managed in-house, by large companies, and are inaccessible to most small businesses. "Cloud computing" will make them accessible as services accessed over the internet.[7] This will have a strong economic impact in making these new technologies available to SMEs, thanks to the lower capital expenditure and reduced in-house expertise required, and the increase in flexibility.

Some sectors deal directly in information. For them there are obvious benefits. Information goods — books, music, videos, newspapers, magazines, games and recipes — can be duplicated and delivered at negligible cost, by substituting the production and transport of physical media with the cheaper transport of bits.

All sectors process transactions. The internet removes the need for physical co-location. Many sales of goods and services, as well as internal transactions, now take place over the internet. This reduces costs. Savings are offered for internet purchases, but the dynamics of online competition can also increase returns to producers.[8] Both consumers and producers benefit from a more efficient economy.

Telecommuting also enables more people to contribute to the workforce. Parents, staying home to raise young children, can have the opportunity to work flexible hours from home. The ability to work from home, connected by broadband networks, will also enable the elderly to remain productive later in life. Tele-presence and real-time video links allow effective remote interaction with colleagues, experts and customers.

Digital connectivity lets local businesses access global markets, and operate more efficiently. It stimulates activity by providing more opportunities for both work and leisure.

3.3 Health

The efficiency and quality of delivery of health services can be enhanced by the use of digital technology, giving rural patients the access to expertise currently only available to those living in major metropolitan areas. Universal deployment of high-speed broadband will enable greater use of telemedicine, improving health care outcomes and lowering overall health care costs.

Telecare, remote monitoring and related assistive technologies can enable older and disabled people to remain in their own homes — rather than in hospitals or residential care — saving money by reducing demand for residential care space. Video-chat can allow those housebound to maintain social contact.

Telemedicine is a useful and effective tool in the delivery of care. Improved access to interdisciplinary teams enhances coordination of care, decreases isolation for both patients and their families, and provides timely interventions, all while avoiding the complexities associated with transporting people to multiple providers.

These effects will be of particular relevance in countries with areas of relatively sparse population. A good example is the use of a long-distance wireless network in the southern Indian state of Tamil Nadu to allow hospital-based eye specialists to interview and examine patients in five remote clinics via high-quality video conferencing.[9]

7 http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/benchmarking_digital_europe_2011-2015.pdf

8 http://ideas.repec.org/p/iuk/wpaper/2006-11.html

9 http://tier.cs.berkeley.edu/wiki/Aravind

3.4 Society

"Broadband is particularly important because it delivers benefits right across every sector of society. That's why broadband needs to reach all people, in all nations."[10] **Hamadoun Touré, Secretary-General ITU, May 2010**

The electronic age has already led to profound changes in society, both local and global. Inclusion in the digital society — digital inclusion — has become as important as literacy in ensuring social inclusion and equality of opportunity, from which those outwith are excluded.

Digital technology offers many opportunities for improving access to public services, potentially improving both quality and efficiency. It can boost the quality of life in all communities by providing access to a wider range of opportunity, interaction and experience. With greater access comes better ability to choose services, access education and market information (as either consumers or producers) and membership of various online communities from professional networks, advisory services to special interest or leisure groups.

Web 2.0 and other technologies (for example 3G mobile communications) mean that with improved connectivity, it is not only formal organisations that increase their spread of communications, but also that informal networking and sharing possibilities increase, often spontaneously, in ways that could not be predicted. These possibilities have, for example, transformed the relationships between producers and consumers of arts and culture and in business services.

Advantages of inclusion

- Access to services.
- Access to social capital.
- Time-distance compression.
- Access to broadcasting.
- Improved life opportunities.
- Cultural inclusion.
- Educational opportunities.
- Remote working.
- Telepresence.
- Sustainable communities.

The *Inclusion Through Innovation* report[11] explores how information and communication technologies (ICT) can be used to make mainstream public services – including education and training, health, employment and benefits and housing – more effective, efficient, and accessible for socially excluded groups. It sets out numerous examples of innovative uses of technology to address exclusion.

Social cohesion depends in large measure on equalisation of access to public services and of the distribution of economic activity. Digital connectivity affords wider access to public services such as education and health, together with efficiencies that reduce costs of delivery.

Civil society also plays an important role in social cohesion and good governance. Civil organisations are especially strong in parts of Scotland and have been transformed through ICT. They use internet to broadcast their messages, mobilise campaigns, communicate with members, organise events and provide information. A thriving civil society is essential for social, political and economic development in Scotland and these loose networks especially benefit from digital communication in rural areas.

Society benefits from a more efficient workforce. Broadband is reducing travel, by enabling tele-work, as well as tele-health, tele-education and tele-play. While workers receive the most obvious benefit (in the form of reduced travel time and access to more employment opportunities), employers also report substantial saving and productivity gains.[12] Society also benefits from reduced congestion, pollution and energy consumption.

However, without intervention, the market will not provide the infrastructure required to extend the benefits of a digital society to those who need them most. The factors — of distance and deprivation — that favour social exclusion, lead also to digital exclusion, to compound their disadvantage.

10 http://www.egovmonitor.com/node/36327

11 http://www.cabinetoffice.gov.uk/media/cabinetoffice/social_exclusion_task_force/assets/publications_1997_to_2006/inclusion_final_report.pdf

12 http://siteresources.worldbank.org/EXTIC4D/Resources/IC4D_Broadband_35_50.pdf

3.5 Digital inclusion

Digital inclusion — the inclusion of every individual within the digital society — requires that each person has technical means of access, skills that enable autonomy of use, and appropriate social support networks. Digital inclusion should be universal, because it stimulates social inclusion and extends equality of opportunity.

Uptake of digital communications varies widely across the country. People remain unconnected for a variety of reasons of cost, availability and choice. ***Some hae meat and canna eat, and some wad eat that want it.*** Those already most disadvantaged are least likely to be connected.

The Ofcom Communications report for 2009 identified that only 39% of households in Glasgow were connected to broadband, which compares with 73% of households in Aberdeen and 72% in Edinburgh. Scotland as a whole had a broadband take up rate of 60% — which is 8% less than the UK average.

Ensuring universal access is challenging, savings can be made by leaving the most distant and most deprived unconnected. Delivering broadband to these most difficult cases has a higher than average marginal cost. However, the marginal benefits — the positive externalities — will also be greater than average.[13]

Those who would naturally be left out by partial provision are those who are most inaccessible: the geographically distant and economically deprived. They already account for a disproportionate share of the costs of social provision. Because of their inaccessibility they typically receive lower than average services, provided at a greater than average cost. So, delivering improved services to this sub-population — better access to healthcare and education, and improved social inclusion — at reduced cost offers correspondingly high potential savings.

Until we achieve universal access, we cannot achieve the full benefits of digitisation. Until that time, legacy systems must be maintained to cater for the unconnected minority, at disproportionate cost. Until that time our education systems cannot presume universal digital access, nor aspire to universal digital literacy.

It is clear, however, that access is only a first step. A number of digital divides remain important and without policies to address them, universal access will not lead to universal digital inclusion.

These digital divides include:

- generational (younger people are more tuned in than older people)
- technological (communities with slower connectivity are left further and further behind)
- wealth (those who can afford neither access nor substitutes such as travel, are excluded)
- gender (men generally have better access to digital technology — although this may be changing)
- educational (those with higher levels of education are more likely to benefit)

Many of these digital divisions exacerbate existing inequalities and disadvantages. However, experience shows fast learning of digital technology. 'Catching up' can be relatively swift, and can help address the other disadvantages. It is not likely to happen without targeted interventions.

13 http://www.ofcom.org.uk/research/cm/cmrnr09/scotland/cmrnrscot.pdf

Whole communities risk being "left behind" in the transition to a digital society.[14] Indeed, we might extend the notion of "social exclusion" to include "digital exclusion" since more and more opportunities and services depend upon online communications.

Scotland has some of the most deprived neighbourhoods in Europe. Ensuring access for members of these communities must be an essential part of urban and social regeneration strategies.[15]

Remote and peripheral rural regions comprise a large part of the territory of Scotland and pose particular problems in terms of communications infrastructures. Digital communication can help to improve communications within scattered populations and between them and the outside world. This has advantages for logistics and tourism. Scotland's rural populations are demographically older, and poorer than those in urban Scotland. The costs of transport and communications are higher in these areas, meaning that even less poor people are worse off.

Communities for inclusion

- Deprived urban neighbourhoods.
- Remote and peripheral regions.
- Small- and micro-businesses.
- Arts and cultural organisations.
- Minority language communities.
- Ethnic and migrant groups.
- Women.
- Aged and infirm.

Many small- and micro-businesses, especially those in rural areas, do not have sufficient funds for large-scale infrastructural investments (for example in telecommunications) and are further disadvantaged through lack of easy access to markets and supplies, logistical facilities etc., which makes them less competitive. They are able to gain good connectivity only by pooling resources and this can be stimulated by an outside facilitator.[16]

Arts and cultural organisations, as well as creative industries more generally, represent a significant potential area of economic growth as well as enhancing the quality of life. Many small arts providers and festivals could use internet access to reach new audiences.[17]

Minority language communities, such as Gaelic, benefit significantly from being able to use digital technology and Web 2.0 applications to provide access to language resources and communicate with users around the world. Digital communications can be an important way of promoting and preserving regional identities more generally through archiving of music, story-telling, poetry and local history.

Ethnic and migrant groups are likely to have less income. They would also potentially benefit from increased connectivity in order to find new work opportunities and maintain links with compatriots.

Women have traditionally had less access to technology, but with more accessible applications, they are able to take advantage of digital communications. Women represent a hidden resource in rural areas if they have access to wider opportunities through business coaching and other support.[18]

14 Many of these are being explored through projects at dot.rural, the rural digital economy hub at the University of Aberdeen.

15 Bailey, N., J. Flint, et al. (2003). Measuring Deprivation in Scotland: developing a long term strategy. Final Report. Edinburgh, Scottish Executive Central Statistics Unit.

16 Both Scottish Enterprise and Highlands and Islands Enterprise have been active in this respect

17 Creative Scotland has invested in schemes to promote the creative industries using the transformational impact of new digital technologies.

18 A project in remote coaching of women in new businesses is being conducted at the Robert Gordon University and there are NGOs who facilitate women in rural businesses such as WiRE (Women in Rural Enterprise).

3.6 Conclusions

A Digital Scotland strategy should give everyone an opportunity to benefit from the digital age. Citizens increasingly require telecommunications access of a high standard for work, education and leisure. Individuals can only be members of the ubiquitous information society in so far as their telecommunications infrastructure allows them to participate.

Widespread access to broadband is becoming a key economic driver, and universal access a central factor in ensuring equality of opportunity. Universal access will enhance the competitiveness of Scottish industry, increase social cohesion, and be an important component of any national balanced growth strategy.

Infrastructure development will stimulate demand from remote work, tourism and rural business, healthcare and education, among others. The market alone, however, will not provide universal digital inclusion, since many of the social benefits have no influence on the purchasing decisions of existing businesses or individual consumers.

A Digital Scotland strategy should incorporate the development and use of an integrated information infrastructure into our long-term strategic master plans, alongside established strategic issues such as culture, transport and energy. In particular, to underpin digital inclusion, national, regional and community planning should ensure that the infrastructure — technical means of use — required for information society services is accessible to all.

Digital literacy has already become a key skill for people in many different aspects of their lives and equipping people with computer skills has arguably become just as important as reading, writing and arithmetic.

Schools and colleges are increasingly utilising IT across a range of subjects, exposure to these uses will develop digital skills in those in education. To develop social support networks and skills for those not in education, we should take advantage of existing infrastructure and shared facilities. For example, policies aimed at rural areas could build on existing resources such as schools, post offices, local shops, post vans, buses, boats and trains.

Existing infrastructures such as community centres, churches, youth clubs, pensioners' clubs, sports facilities, nurseries, mums and toddlers clubs etc., could be used to access otherwise disadvantaged communities. These existing infrastructures mostly exist in supervised facilities that could also become digital hubs, providing access, as well as support from peers, outreach workers and volunteers.

4 Infrastructure

The first part of the UK National electricity Grid was opened in 1930 — in central Scotland. By 1944 two thirds of homes in the UK had an electricity supply. Some rural areas of Scotland remained unconnected until the 1960s.

Without intervention history will repeat itself. If we invest wisely, then in less than 30 years, our children and grandchildren will look back in wonder at a time when some families survived without gigabit internet.

	km	Mb/s
VDSL2	< 0.5	< 100
3G	< 1.5	< 10
DSL	< 2	< 25
WiMAX	< 20	< 100
Cable	< 150	< 300
Fiber	> 300	> 10,000,000

Availability of information transmission infrastructures with a sufficiently high capacity is only one of the factors that will influence digital inclusion and the development of the information society. However, fixed and mobile connectivity are necessary underpinning infrastructure.

Broadband subscriber connections are available throughout Scotland through a mixture of technologies. A minimum download speed of 512 Kbit/s ensures a basic level of service adequate for sending and receiving email and for internet browsing. However, it is insufficient for efficient e-services, image transmission, or the uploading and downloading of music and video clips. In addition, some areas are served only by satellite connections with limited bandwidth and high latency. These cannot effectively support interactive applications such as teleconferencing. Increasing upstream and downstream bandwidths with low latency are required.

4.1 *The pace of change*

Just as computer performance has increased exponentially for several decades, following Moore's law, so median domestic broadband speeds are expected to follow Neilsen's Law, doubling every 20 months — increasing 64-fold over the next decade. Novel applications will exploit this new capacity.

We are entering a new age of optical communication.[19] This will bring new opportunities for real-time multimedia interaction — and for distributed sending, storage, and analysis of data. These will be used to develop new forms of community, enable new efficiencies, and generate new markets that contribute to economic growth.

Regions with advanced information infrastructures — those "ahead of the curve" — will have new opportunities for both innovation and exploitation. We agree with the Caio report[20] that, "Broadband/NGA will become a critical digital utility, essential to the competitiveness of any country and to the quality of life of its citizens."

High speeds, symmetric connections and low latency are required for interactive multimedia, which will underpin new applications in healthcare and education. Roll-out of future advances in communications technology to businesses and to the home will lead to further innovation and disruptive changes in social and commercial services. We cannot predict how these technologies will be used, but we can predict some changes in technology, and use these expectations to guide our strategy.

19 Optical fiber has been used for communications for several decades. These technologies are now competitively priced for consumer applications, including fiber to the home, bringing optical speeds to consumer markets.

20 http://www.berr.gov.uk/files/file47788.pdf

Broadband speeds currently (2010) experienced in Scotland range from 0.3 Mb/s to ~50 Mb/s.[21] Already, we find 0.5 Mb/s is inadequate to support a family's use of many of today's applications, such as streaming video and video chat. If we accept 2 Mb/s as a benchmark minimum recommended speed for connection to today's internet (many would set it higher than that), then we should require 16 Mb/s in 2015 and 128 Mb/s in 2020, just to maintain our relative position. This will be our recommendation. However, new installations should normally aspire to be leading edge so they do not quickly become obsolete.

The current spread represents a ten-year lag in digital access between the extremes of advantage and disadvantage. This long lag slows the pace of innovation, since new applications that rely on leading edge capabilities must wait ten years for universal provision to catch up. Our suggested target would close this gap in Scotland to about seven years — still longer than the approximately five-year lag, from innovation to universal provision, that corresponds to Finland's target of universal access to 100 Mb/s in 2015.

A compressed full-length movie may be represented by around 1 gigabyte of data. It would take about five hours to download at 0.5 Mb/s; at 10 Mb/s it would take about 15 minutes — providing you had sustained access to that speed.

In fact, you are most unlikely to have sustained access to your nominal speed. Just as the water company expects no one to leave every tap in the house running fully open for every minute of every day, so your broadband provider expects that no one will use the full bandwidth of their internet connection for every second of every month. In fact, you share your nominal bandwidth with a number of other subscribers.

The ***contention ratio*** of your connection is the number of subscribers who share your nominal broadband pipe. Contention ratios of 50:1 are common — and of course each subscription typically serves multiple users within the household. If all 50 subscribers want to download a movie at the same time, it will take each one 50 times as long: more than ten days at 0.5 Mb/s, and more than 12 hours at 10 Mb/s. So, even with a 10 Mb/s connection, if you want to come home and watch a movie, it's better to start the download before you leave for work.

At a contention ratio of 50:1 each 1 Mb/s of bandwidth, used flat out, day in, day out, will provide only 6.5 GB of data to each subscriber per month. As 'always-on' usage increases, and the number of users and devices connected to each subscriber line increases, delivered speeds will have to go up, or contention ratios will have to go down, just to maintain current levels of user experience.

For a given level of subscriber demand, it is preferable to have higher speeds with correspondingly higher contention ratios. A speed of 100 Mb/s shared at 500:1, compared with a 10 Mb/s service at 50:1, will give quicker responses at times when demand does not exceed supply, and equivalent performance when there is maximal competition for bandwidth.

Internet architecture

The internet is an extensible network of networks. The component networks are autonomous systems (AS) (these include a multitude of different organisations — ISPs, corporations, universities, government agencies, etc.). Any network that adheres to the internet protocol can connect to the global network by negotiating ***"backhaul"*** connections to one or more already connected networks. These backhaul connections determine the maximum bandwidth available from the local network to the rest of the world.

21 http://broadbandforall.net/

Network traffic is broken into many small packets, which travel independently, possibly by different routes. Different component networks use different technologies to transport these packets of information — fiber, twisted pair, cable, WiFi, 3G and 4G mobile — and different parts of a single logical network may use different technologies. Routing information, network traffic, and sometimes payments, are passed between networks according to peering and transit contracts.

Peering is a symmetric agreement, for mutual benefit, where each network accepts incoming traffic from the other and forwards it for onward routing to its destination. Peering arrangements may only cover traffic to destinations within one of the participating networks, and are often "settlement-free", which means that no payments are made.

Transit is an asymmetric agreement, where one client network pays the other to provide connectivity to the global internet. Some networks merely carry traffic from one network to another, facilitating global connectivity; some are the internal networks of organisations and corporations; others exist to connect individual subscribers to the global internet. Many combine several such functions and have multiple peering and transit agreements, providing redundant connections to the global internet.

The economics of these agreements reflect a complex symbiosis. For example, an ISP typically charges end users for their connection to the global internet, but may also negotiate cost-free peering arrangements to deliver that connection, because it provides other internet users with access to its customer base.

It is common to distinguish core, intermediate (middle-mile) and access (last-mile) networks. Middle-mile provision — access to backhaul — is a major issue in reducing the price of broadband internet provision by non-incumbent operators. Internet bandwidth is relatively inexpensive to purchase in bulk at the major Internet peering points. However, middle-mile access, where bought from an incumbent operator, is often much more expensive. Building an intermediate fibre network is capital-intensive. For this reason, many proposals for government broadband stimulus initiatives are directed at building out the middle-mile.

To ensure universal access to competitive digital infrastructure for the foreseeable future, we must ensure that Scotland has an integrated backbone network that brings high-speed backhaul within reach of every home and business. Integrated, here, means that interconnected component networks, administered by a variety of communications providers, which support each other through peering and transit arrangements, should deliver a single, robust, redundant, and extensible logical network, connecting Scotland to the global internet.

Openness has enabled the global development and growth of the internet. Openness enables universal participation and contribution. To foster innovation, entrepreneurship and competition, Scotland should ensure an open market giving both established and new entrants access to the backbone via equitable peering and transit arrangements, allowing them to offer end-user connections to homes, businesses and communities.

4.2 Technologies

Technologies currently available allow us to plan new additions to the backbone network with sufficient capacity to accommodate foreseeable need over the next 30 years. The table on page 15 gives rough estimates of the distance and bandwidth limitations for single hops of various technologies for data transport. The details may be debated, and will vary with local conditions. Further improvements can be expected in electrical, radio and optical technologies. However, the glaring disparity between optical fiber and the rest is inescapable. It will remain.

Fiber is a necessary technology required to underpin next generation access at national scale, and fibers laid now are expected to have a lifespan of over 30 years with zero maintenance, other than repair of accidental or malicious physical damage.

In order to upgrade the capacity of a fiber link, as new technology becomes available, only the two endpoints have to be replaced, while the physical channel itself (the fiber) doesn't need to be changed or improved. From the technical perspective, it suffices to replace a modular transmitter on each end. For this reason, fiber represents a more future-proof asset than other media. Maintenance and repair costs of fiber networks are much lower than those for copper networks of comparable size.

Optical cables can typically be installed in duct systems in spans of almost unlimited length. A single fiber can already support 155 channels, each carrying 100 Gb/s over several hundred km. A 25 mm cable can include ~100 fibers. So a single cable could provide a 1 Gb/s channel for each inhabitant of rural Scotland (pop.~1.5M). Regional disparities in digital access could be equalised for decades to come, by a suitably planned core optical fiber network, owing to its practically unlimited transmission capacity.[22]

Where new physical data connections are laid, they should be based on optical fiber. Compared with copper, carrying electrical signals, fiber has vastly superior performance, costs for installation are similar, and for maintenance fiber is cheaper. Excess ***dark fiber*** (fiber left dormant, that does not yet carry optical signals), can be installed at low marginal cost, and later be ***lit***, to meet new demand.

Wireless connectivity can be used effectively to provide high-speed communications over long distances for limited populations.

Wireless signals can be used to transmit digital signals. However, bandwidth is limited, so the use of wireless spectrum is regulated by Ofcom. Large parts of the spectrum are licensed for television and radio broadcasts and for mobile services. Others are "unlicensed", but their use is regulated. In the UK for example, the power allotment for 2.4 GHz (used for WiFi and other services) is about one tenth of that allowed for products sold in the US. Increasing the allowable power levels for certain licence exempt devices in less populated geographical areas could facilitate new services. In addition, parts of the spectrum licensed for broadcast and mobile coverage will remain unused in some parts of the country. Opening up this 'whitespace' could provide new opportunities for connectivity, particularly in remote regions.

Greater flexibility could be exploited to enhance services such as delivery of higher speed broadband to rural communities. There are many wireless devices operating on unlicensed spectrum that provide 300 Mb/s channels over distances of more than 50 km — up to 200 km at lower speeds.[23] The number of channels is limited by the spectrum available.

Copper A number of technologies use copper wires and cables to carry digital communications. These deliver limited bandwidth over limited distances. However, existing copper wiring can be used to deliver limited broadband access without rewiring.

ADSL Asymmetric Digital Subscriber Line uses a twisted pair of wires (originally designed to carry analogue telephone signals). Older ADSL standards can deliver 8 Mb/s to the customer over a distance of about 2 km. The latest (2009) standards can deliver up to 24 Mb/s over this distance. Distances greater than 2 km significantly reduce the data rate achievable.

22 Optical Fiber Communications, Principles and Practice, John Senior ISBN: 9780130326812

23 http://www.motorola.com/staticfiles/Business/Products/Wireless%20Broadband%20Networks/Wireless%20Ethernet%20Bridges/PTP%20600%20Series/_Documents/Static_files/Fact_Sheet_PTP600.pdf

In dense DSL deployments, where a large bundle of twisted pairs runs from a phone exchange, there can be significant "cross-talk" effects. Electromagnetic interference builds up as the number of "active pairs" (cables carrying DSL frequencies) increases. So performance can degrade as new local users sign up.

Coaxial Cable (Co-ax) is designed for data transmission. It can deliver 300 Mb/s over a distance of 150 km.

Power Line Transmission (PLT) and Broadband over Power Line (BPL) Cables used to provide electrical power can also conduct high frequency signals that carry digital information. The highest information rate transmission demonstrated over power lines uses radio or microwave frequencies transmitted over a single conductor, to achieve data rates in excess of 1 Gb/s. Medium-voltage power lines have also been used to propagate multiple WiFi channels over a single conductor. It is not clear whether these techniques could be used in Scotland.

Domestic mains power networks can be used to provide broadband internet connections, allowing the premises served by a single circuit to share a 135 Mb/s connection to the backhaul, the bandwidth at each outlet being limited to ~2.7 Mb/s. Again, these techniques are unproven in the UK context.

Satellite The distance from northern Scotland to a geostationary satellite, positioned over the equator, is ~39,000 km. The speed-of-light round-trip to such a satellite takes ~260 ms, so the round-trip latency to your server is more than ½ second; where there is contention the delays are amplified, and all this is in addition to the normal internet latencies due to packet processing times. Recent tests have recorded total round-trip delays ranging from a minimum of 720 ms, up to 1200 ms. Such delays make any highly interactive internet use impossible. Satellite broadband is also inherently asymmetric, and provides limited bandwidth. Satellite technology can provide basic services such as email and access to static web pages, but it will not support applications that exploit high speeds and low latency to provide an interactive experience.

4.3 Implementation

The roll-out across Scotland of Next Generation internet Access[24] (NGA—which provides high speeds and low latencies beyond the capabilities of extended copper or satellite connections) will be particularly problematic, by reason of Scotland's particular physical and social geography.

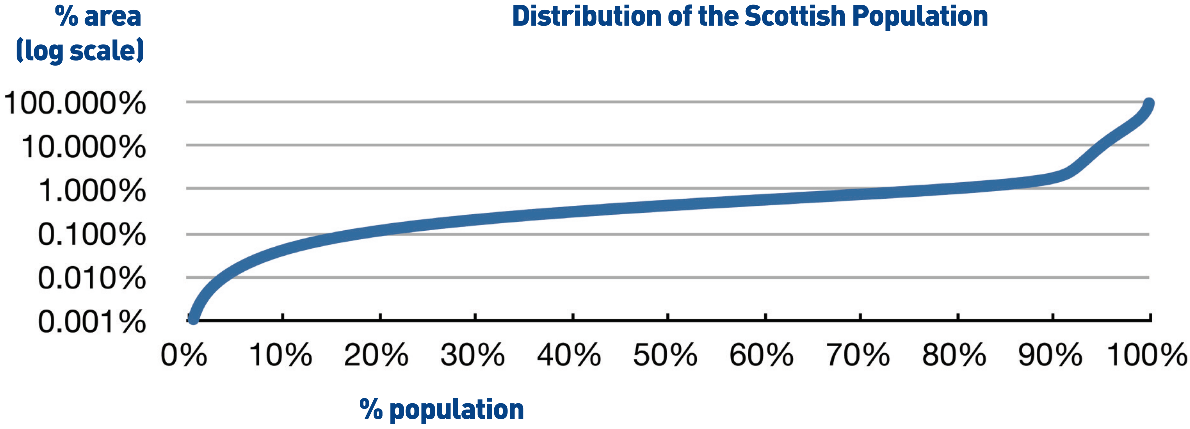
The main cities have populations as follows: Glasgow 577,980, Edinburgh 446,110, Aberdeen 179,950, Dundee 141,930, Inverness 42,400, Stirling 33,060. Most of the 5.2m population is concentrated in the cities and the central belt.The rural population is about 1.5m. Population densities above 70 people per square kilometre (p/km^2) (a figure which corresponds roughly to the Finnish criterion[25] for a built-up area) are shown on pp 30 – 31. We also show areas with more than 7 p/km^2, to demonstrate how population is distributed. There are isolated pockets in the West, and more contigous areas along the East coast, in the borders, Dumfries and Galloway, and the Northern isles. Future growth is more likely in these areas than in the even more sparsely populated areas of the northwest. These maps highlight the difficulty of designing a fiber network that will come within reach of all of every community.

24 http://www.youtube.com/watch?v=fgZZDCn6TZw

25 See the 'Benchmarks' section later in this report.

We estimate that approximately 40,000 km of network is required to come within reach of every dwelling and business in Scotland — both the water and sewerage networks are roughly this big, and we take this figure as a working approximation for the size of the fiber network required for similar coverage.[26]

However, the population distribution outside the major cities suggests that wireless will remain an important technology for digital communications in Scotland. The Scottish census provides areas and populations for over 40,000 "output areas", locally-defined areas with an average population of 120 people (minimum 50). The graph below tells us that we can include 20% of the population within a set of output areas that covers just over 0.1% of Scotland's land area; 1% of the land area includes almost 80% of the population, and the last 20% of the population lives in the least populated 99% of the land area. The last 5% of the population is particularly sparsely distributed, over 90% of the country.



There is already extensive fiber infrastructure reaching many parts of Scotland. This has grown in response to market opportunities. Without open collaboration, this organic growth has led to patchwork coverage. Some areas are served by multiple providers, with unused capacity, while others remain beyond reach. The investment in, and use of this infrastructure is distorted by differences in rating regimes applied to different technologies and different operators.[27] Strategic planning is obstructed by lack of transparency — there is no national map of our communications infrastructure.

Costs

Detailed information on practical aspects of fiber provision are given in the EU FTTH Handbook.[28] The relative costs of laying fixed backbone, intermediate, and access networks are reported to be in ratio 1:3:10, and 80% of these costs is accounted for the holes and poles required to lay or carry the cables.[29] It therefore makes sense to reuse existing infrastructure, such as sewers[30] or existing transmission poles and pylons[31], wherever possible, and to lay communications ducting, at minimal marginal cost, in conjunction with civil works (as is already happening in Orkney), new build and refurbishment.

The per population costs clearly increase with increasing distances and decreasing populations, so small, distant communities are disadvantaged.

Currently, every fiber used is valued for business rates, at least for new entrants to the market, on a per fiber km basis. Costs of hundreds of pounds per fiber km are reported, with 'volume discounts' for multiple fibers on the same route. Again, this disadvantages small and remote communities, as well as those wishing to install new fiber in competition with established providers.

26 The water and sewage networks have disconnected components, but interconnecting these would add only a small overhead.

27 http://www.computerweekly.com/Articles/2009/11/04/238417/How-the-government-taxes-UK39s-broadband-future.htm

28 http://www.ftthcouncil.eu/documents/studies/FTTH_Handbook.pdf

29 http://arstechnica.com/telecom/news/2010/03/fiber-its-not-all-created-equal.ars/

30 http://www.h2onetworksdarkfiber.com/latest-news.php?n=Dundee-to-become-the-first-Scottish-Fibercity

31 http://uk.reuters.com/article/idUKLNE62A00M20100311

4.4 Conclusions

To ensure sustainable access to competitive speeds for each community we must ensure backhaul is accessible. Once affordable backhaul is within reach of every community, the rest will follow, from a mixture of commercial and community provision. For long-term viability we should plan for demand to grow to gigabit/s speeds. Only fiber will meet this national backhaul requirement. Where new installation is required fiber is at least as cheap as copper.

Obstacles to the efficient use of fiber to provide a backbone network include both the rating regime, and a lack of the open access that is required to develop cooperative competition. Networks effects mean that collaboration, which is essential to get optimal coverage across Scotland from the fiber investments of several competing providers, can provide mutual benefit. Openness is required to ensure competition, both in the extension of the fiber network, and in local access provision where we expect local innovation and specialisation to introduce new technological and business models adapted to local geographies and economies.

The rating regime is also an obstacle to rollout of 3G and 4G mobile wireless services in remote areas, even where backhaul is available. Every mast is rated, and we understand that valuations are broadly similar across the UK. It would make sense to base the rating valuations of masts on the population they reach. Over 10% of the population of Scotland lives in population densities greater than 10,000 people per km^2, while the least accessible 15% live at densities of less than 1000 people per km^2. It is no wonder that providers faced with uniform rating costs choose not to site masts in low density areas.

We propose that every community including an output area with population density above 70 p/km^2 should have access to fiber backhaul. We call this an **accessible community**, for ease of future reference. Our proposal is to make them accessible! The areas with at least this population density account for 92% of the population of Scotland, and 2.72% of the land area. Where community population is low (say < 1000) wireless technologies can be used, both for connection to remote backhaul and for local access distribution. Where wireless cannot provide the minimum bandwidth required at low enough contention ratio, a fiber connection is required.

This 92% cutoff point occurs just at the kink in the graph of area against population. Along the whole curve, it gets harder to connect people in successive areas as they are more dispersed. This kink is the point at which it suddenly gets harder faster. Some of the remaining 8% will be within reach of the backhaul installed to reach the accessible communities, but we have not quantified this effect.

Existing power restrictions on wireless transmission, which are justified in high-density areas, may be unhelpful in sparse rural settings. Extending the available spectrum would increase the bandwidth available (both through increased availability of white space and reuse of licensed spectrum in areas where licensee is not active). We anticipate that wireless point-to-point links carrying 500 Mb/s or more could be built using multiple channels, given suitable spectrum allocation.

Where there is existing cabling, of course it should be used for local access, as long as it provides acceptable performance — but acceptance will erode as bandwidth requirements increase.

5 Content and access

Public services can play a key role in fostering the take-up and use of digital technologies. By exploiting digital technologies public services can be provided more effectively at lower cost. Encouraging wide-spread use of digital access to government also increases digital participation — with consequent benefits for all areas of society, including industry and commerce.

Public procurement of open source solutions can stimulate futher development and use, because open source allows others to reuse and build on public investment. Similarly, open publication of public data stimulates both effective use of this data to the benefit of the local economy and innovation that can seed the development of new products and services.

Scotland has invested in the use of digital technologies to deliver and enhance a wide range of social services. But those without access are excluded from the benefits of these initiatives. Universal digital inclusion will further increase the reach of social services, and hence social inclusion. It will also reduce costs, by making redundant some outdated systems which must currently be run in parallel to serve these populations.

Two examples, from health and education, were given earlier in this report, but we highlight here some of the investments already made, the impacts of which will be extended by digital inclusion.

5.1 Health

The Scottish Centre for Telehealth[32], part of NHS 24, has already been helping individual NHS boards devise ways of using technology to reach out to patients in our more isolated areas and those with mobility issues. Work is now underway to establish nationally deliverable telehealth services. Their website provides numerous case studies of the use of telehealth to deliver specialist services efficiently to people in their own homes and communities. Demand, particularly in rural areas, threatens to exceed services available.

5.2 Education

Internet access provides new opportunities in education. Online content can be interactive and will include real-time interaction with remote peers, experts, and environments. Online content can be used to roll out innovations in curriculum and delivery immediately available to an entire population of students.

Internet access enables distance learning, the benefits of which spill over to society as a whole. Distance learning expands educational opportunities, both in the classroom, by giving students access to expertise and experiences not offered at their local school and for those who may be physically unable to attend.

Scotland has already invested in both access and content. Pathfinder[33] is an initiative that has delivered high speed internet access to over 1,200 sites (including primary & secondary schools, council offices, libraries and harbours) across 7 of Scotland's rural and remote Local Authorities (Scottish Borders, Dumfries & Galloway, Argyll & Bute, Highland, Moray, Orkney Islands and Shetland Islands).[34] We have looked most closely at the Pathfinder North project that covers the Highlands. This project was mainly funded by the Scottish Executive (now Government). The Pathfinder networks were originally contracted to THUS plc which became part of Cable&Wireless Worldwide in 2008.

Glow[35], is a Scottish national intranet for education. Glow will break geographical and social barriers and allow joined-up working the length and breadth of Scotland. This will transform the way education is delivered. It will work alongside Curriculum for Excellence to build capacity and ensure universal access to a first-class education for Scotland.

Students with suitable connections are able to access these materials and other learning resources over the internet, when not in school. Since many homes have no internet access and no computers, alternative access outwith school hours is required to ensure that no child is excluded.

32 http://www.sct.scot.nhs.uk/
33 http://www.pathfindernorth.co.uk/benefits/how-fast/
34 The backbone network built to deliver Pathfinder could enable wider deployment of Internet access.
35 http://www.ltscotland.org.uk/glowscotland/about/Whatisglow.asp

5.3 Government

Already a wide range of government services can be accessed online, either providing information on how to access public services, or increasingly to fully carry out all of the functions of a particular service, for example Her Majesty's Revenue and Customs accept self-assessment tax returns and payments online. Information on services from advice on foreign travel to finding out how and where to register a birth are all found through the Government website www.direct.gov.uk. Every local authority in the country also provides information and opportunities to access services online. A further roll-out of government services online is planned for 2012.

Government can also stimulate development of the digital society by making public data "open"—i.e. freely available for use and, importantly, reuse. Providing open access to data not only reduces costs, by removing the need for registration and authentication of both internal and external users. It also stimulates innovation and entrepreneurship by providing opportunities for innovative "mash-ups" that bring data together in novel ways, for analysis, visualisation and exploitation.

Advocates of open access argue that government data is public data, collected and analysed at public expense. Where this data has social value, economic theory suggests it should be made available at marginal cost in the digital world, this marginal cost is practically zero. In fact, making data open reduces the costs of managing authentication and access. The UK Government publishes much of its data through the website www.data.gov.uk, building on the work of the Open Knowledge Foundation. We believe that Scotland should establish its own open data portal to stimulate the reuse of public data resources for the analysis, management, exploitation and marketing of social assets.

5.4 Broadcasting

Many of the aspects of broadcasting covered in the Digital Britain report are issues of UK national policy, where Scotland has no relevant devolved authority. However, one aspect of particular relevance to Scotland is the increased move by broadcasters to make their content available online, to view at the time of convenience of the viewer. The success of the BBC iPlayer is a particular example. This makes broadcast content available to those beyond the reach of existing transmissions, provided they have broadband access.

We expect this trend to continue and envisage a future where many viewers access all of their television and radio online. We therefore recommend that current public services obligations of broadcasters should be extended to include online dissemination of content over the internet.

5.5 Access

Across Scotland there are varying gaps between availability and uptake of digital connectivity. Public internet access in supportive environments is required to allow those who remain unconnected by reason of choice or deprivation.

The provision of public open access WiFi can also stimulate the local economy by providing locals and visitors with access to location-based services. For example, Historic Scotland is the largest operator of visitor attractions in Scotland, with 345 properties, ranging from neolithic standing stones to historic castles. Of these, the vast majority are unstaffed, and many lie in relatively remote areas. WiFi at these sites could enable much richer location-based interpretation, while also providing a platform for services directed at residents, tourists, or both.

Pathfinder provides connectivity with speeds up to "300Mb per second, which is not shared with anyone else". In fact the Pathfinder network includes unused capacity particularly outwith office hours, and surplus backhaul is available. Technically this could be used to contribute to the Scottish backbone network, to provide high-speed internet for public access, and to provide backhaul for mobile operators and community networks. A variety of different stakeholders would need to collaborate to establish appropriate commercial and management arrangements.

Traditionally the Highlands and other remote and rural areas have been last to benefit from infrastructure developments of many kinds, so it would be beneficial for the region to make best use of its communications infrastructure to deliver connectivity in advance of many other parts of the UK.

6 Benchmarks

We have looked at the current provision and future strategies of a number of countries to see what lessons Scotland could learn. These include Sweden, Finland and New Zealand, which are similar to Scotland in terms of geography and population density, and the USA which plays a leading role in the world economy and development of digital standards and technologies. We also draw attention to a couple of local initiatives that might inspire similar projects in Scotland.

6.1 Sweden

The Swedish Government released a broadband strategy in November 2009 which pledges that by 2020 90% of all households and businesses should have access to broadband at a minimum speed of 100 Mbps in 2020, and 40% should already have access to broadband at that speed by 2015. The following points are taken from the executive summary:

> The Swedish Government presents a Broadband Strategy for Sweden that clarifies the policy focus: a broadband policy adapted to the situation and challenges we face. The Government is continuing its efforts to improve competition and conditions for market players through its broadband strategy.
>
> The overall objective for Sweden is to have world-class broadband. A high usage of IT and the Internet is good for Sweden, in relation to growth, competitiveness and innovation. It contributes to the development of a sustainable society. It also helps in meeting challenges in the shape of increased globalisation, climate change and an ageing population in a scarcely populated country.
>
> To meet the challenges it is essential to have access to high-speed broadband throughout the country. That implies that ninety per cent of all households and businesses should have access to broadband at a minimum speed of 100 Mbps in 2020. Forty per cent should already have access to broadband at that speed by 2015.
>
> It is important that Swedish businesses and households in all parts of the country are able to benefit from the opportunities that access to powerful broadband gives. In order to change traditional working methods, enable development of new services and business models and new patterns of behaviour, all households and businesses should also have good opportunities to use electronic public services with broadband access.
>
> As more and more services in society become digital, everyone must be given the opportunity to be connected. Everyday life should run smoothly: It is, in essence, a matter of democracy and rights.

The underlying principle is that electronic communication services and broadband are provided by the market. The Government should not control the market or technical development. Our task is to establish good market conditions and eliminate obstacles to development. This entails ensuring that there is a relevant regulation in place.

To meet the targets and provide the market with the necessary conditions to deliver services and to invest in broadband throughout the country, the Government proposes initiatives in several areas. These include providing good conditions for competition, a revised model for spectrum management and promoting investments in broadband in more remote areas.

The municipalities planning responsibility is clarified by strengthening the focus on electronic communications in the Planning and Building Act.

The Swedish Post and Telecom Agency will be assigned to investigate how suitable frequency bands for electronic communications can be used for increased availability in areas that lack access to broadband or have broadband of low capacity and quality.

The level of functional access to Internet within the universal service obligation will also be reviewed.

Municipal initiative in Västerås [36]

In 2000, Västerås was the first municipality in Sweden to form its own commercial company to build and operate an open urban network, allowing the users themselves to decide which services they want. The Västerås network today covers the entire town.

With its 22,000 household connections, Mälarenergi is already a large player on the urban network market. It also has 1,700 companies, all the local state-run schools, council offices, companies and all of the Västmanland county council healthcare clinics.

Mälarenergi Stadsnät connects properties and service providers to the urban network. The users in companies, organisations and private households are, in turn, linked to the urban network via their landlord's property net.

Tenants' associations and housing associations can also build property nets and hook themselves up. Once the property is connected, the companies, organisations and households are free to link up. This usually takes place with the user paying a fixed monthly fee for the use of the network via the service provider(s) chosen.

The Västerås model is an organisational concept that helps provide structure and facilitates sales, contract-signing, start ups and contact with the service supplier. The model is based on a system whereby the network owner and the service providers share the revenue generated by the urban network, with the service providers offering their services direct to the users instead of running their own broadband connections to the customers they want.

The service providers pay for gaining access to customers who are already connected to the network. The users hook up to the system via a normal wall data socket and then buy the services they themselves want direct from the relevant providers. The Västerås urban network offers connections at speeds no less than 10 Mbit/s, but the network has a transfer capacity of between 100 and 1,000 Mbit/s.

36 http://www.packetfront.com/en/news_events/success/malarenergi.html

6.2 Finland [37]

The Finnish Ministry of Transport and Communications has enacted a law that will oblige telecommunications providers to offer at least 1 Mbit/s internet connections to all of the country's 5.3 million citizens by 2010 and 100 Mbit/s by 2015.

> The Finnish Government reviewed its communications policy guidelines in December 2008. The guiding principle has been that telecommunications operators are responsible for supplying communications services on market terms but if adequate communications services cannot be provided on commercial terms only, public aid may also be used to ensure that services are available to all.
>
> The implementation will be by subsidised projects which will be subject to competitive tendering. The telecom operator responsible for a project will pay at least one third of the project costs. The responsibility for the public aid – two thirds – will be divided between the state, municipalities and the EU.
>
> Subsidies will only be paid to projects located in the most sparsely populated areas. A total of 66 million Euros in State budget appropriations have been reserved for broadband subsidies. The EU Rural Development Programme will fund Finland's broadband projects with 25 million Euros and the municipalities involved with around 50 million Euros.
>
> ... a built-up area square (250 m x 250 m) is defined as a map square in which at least four households or ca. 10 residents are located and the immediately adjoining map squares of which (750 m x 750 m) have at least 12 households or ca. 30 residents.

Finland has allocated additional frequency in the 1,800 MHz band enabling them to start building 4G mobile networks. As a result, fast 4G networks can be provided with a substantially wider coverage at a lower cost than commonly used 2,600 MHz networks, which require a considerably larger number of base stations.[38]

6.3 New Zealand [39]

The New Zealand Government has released the details of a $1.5 billion ultra-fast broadband investment initiative. The government will partner with the private sector to accelerate the roll-out of ultra-fast broadband services to 75 percent of New Zealanders within the next ten years.

The proposal will result in "Local Fiber Companies" providing and owning a dark fiber infrastructure, which is funded by government co-investment with the private sector.

The rationale is given in a series of questions and answers.

37 http://www.lvm.fi/c/document_library/get_file?folderId=121398&name=DLFE-4072.pdf

38 http://www.ranscope.com/finland-rural-mobile-broadband-coverage-needs-drive-spectrum-allocation

39 http://www.med.govt.nz/templates/MultipageDocumentTOC_41865.aspx

Why is the government investing in broadband infrastructure?

> *Private sector companies have decided, on behalf of their shareholders and as a commercial decision, not to invest in a nationwide network of fiber-to-the-home at this point in time. The government understands this, and so wishes to assist and work with the private sector in improving the business case for ultra-fast broadband. The government is also getting involved in order to encourage the provision of widespread open access dark fiber services, which will facilitate the best possible competition outcomes in emerging markets and encourage innovation in wholesale and retail services.*

What is the government's objective for dark fiber infrastructure investment?

> *To accelerate the roll-out of ultra-fast broadband to 75 percent of New Zealanders over ten years, concentrating in the first six years on priority broadband users such as businesses, schools and health services, plus greenfield developments and certain tranches of residential areas.*

Why is the government only investing in dark fiber?

> *Government investment at that level will facilitate the competitive commercial provision of ultra-fast broadband services over fiber with the minimum regulatory intervention. In very simple terms, this is the most "raw" access to the underlying infrastructure, and provides the best competition outcomes because the wholesale customer has full control and flexibility and has the ability to innovate in downstream services.*

6.4 USA [40]

The US Recovery Act 2009 makes reference to a radically different model of infrastructure provision into premises. It enables public investment in middle-mile to encourage private last mile provision, as well as public last-mile investment. The executive summary includes:

> *Broadband touches nearly every aspect of the U.S. economy, providing Americans with unprecedented opportunities in employment, education, health care, entrepreneurship, and civic participation. For millions of Americans without adequate access to broadband, however, the possibility of falling behind in the knowledge-based economy is real.*
>
> *By leveraging federal dollars, the Administration's Recovery Act investments will expand broadband access throughout the nation and provide more Americans – in both urban and rural areas – with the opportunity to succeed in the digital age. Among the awards are investments in "middle-mile" networks, which connect unserved or underserved communities to the Internet backbone.*
>
> *These investments will maximize the impact of federal dollars by encouraging private service providers to build connections to homes and businesses using the publicly funded infrastructure. In rural areas and areas with low population density that are difficult to reach, Recovery Act awards will fund investments in the "last mile" of service, which will help provide connections to homes and businesses that would otherwise go without high-speed Internet access.*
>
> *Recovery Act investments will also leverage federal dollars by targeting community institutions that provide critical services in urban and rural areas, including schools, libraries, and hospitals. Middle-mile projects will connect these institutions directly to broadband services, helping to improve the quality of their services and exposing new users to broadband opportunities at work, school, and other venues.*

40 http://www.whitehouse.gov/sites/default/files/20091217-recovery-act-investments-broadband.pdf

> *Funding for public computer centers, including those in urban and suburban areas, will promote digital literacy among the new generation of workers through one-time investments in equipment, hardware and software, and basic training.*
>
> *These critical broadband investments will create tens of thousands of jobs and stimulate the economy in the near term. By providing broadband-enabled opportunities to previously underserved communities, these investments will also lay the foundation for long-term regional economic development and foster a digitally literate workforce that can compete in the new knowledge-based economy.*

6.5 Rutland Telecom [41]

A recent report by the BBC highlighted how a community banding together and connecting through Openreach has managed to deliver high speed broadband of 40 Mb/s in Rutland. This UK community raised £37,000 to provide 200 homes with the super-fast broadband that BT could not deliver.

> *Rutland Telecom offers the residents of Lyddington speeds of up to 40 Mb/s. Established telecom firms had said it was not economical to provide fast services to the village.*
>
> *The Rutland Telecom scheme was a joint effort between villagers fed up with slow broadband speeds and a local ICT firm that was reselling BT's broadband.*
>
> *"We found that any company could do, on a smaller scale, what Carphone Warehouse has done and take over BT's network," said Dr David Lewis, managing director of Rutland Telecom.*
>
> *They asked Openreach, the BT spin-off that has responsibility for the UK's telephone network, to supply fiber-optic cable to a street cabinet in the village. It was a slow process and required the intervention of regulator Ofcom but two years later the telco is up and running.*

6.6 Tegola [42]

Tegola is a project sponsored by the University of Edinburgh and the UHI Millenium Institute to develop new technologies that can bring high-speed, affordable broadband to rural areas. It bypasses much of the existing wired access technology to provide wireless access to remote backhaul. An initial testbed has been operating for about two years, delivering ~20 Mb/s shared between ~40 user sites. Users experience speeds of "up to" 20 Mb/s, at a contention ratio of 40:1. Downstream traffic is ~ 50 GB per week.

6.7 Commentary

From Sweden, *"providing good conditions for competition, a revised model for spectrum management and promoting investments in broadband in more remote areas, and, "to investigate how suitable frequency bands for electronic communications can be used for increased availability in areas that lack access to broadband or have broadband of low capacity and quality"* are actions that transfer directly to the Scottish context.

The Västerås model includes *"property nets"* set up by tenants' associations and housing associations. We believe a similar model could apply to community nets in parts of Scotland unreached by the national providers.

41 http://www.relay-rutlandtelecom.co.uk/

42 http://www.tegola.org.uk/

The Finnish account highlights the need for intervention, and the applicability of the EU Rural Development Programme to funding of *"last-mile"* connections. We note that its criterion for a *"built-up"* area, which corresponds to a population density of 70 people per square kilometre over a 750m x 750m square.

A recent comparison of the Finnish and Swedish interventions appears to show that interventions addressing supply or demand can both be effective.[43]

The New Zealand policies highlight the need to *encourage the provision of widespread open access dark fiber services, which will facilitate the best possible competition outcomes in emerging markets and encourage innovation in wholesale and retail services*. In Scotland, the de-rating of fiber would be a key contribution to such a policy.

Although the USA is of a vastly different scale, it includes a range of geography, both social and physical, that makes some parts reasonably comparable with Scotland. Indeed, eight states of the USA have population densities comparable with that of the Scottish Highlands (< 40 per km^2), and parts of the USA suffer deprivations that compare unfavourably with the least favoured parts of Scotland.

The US strategy highlights the *unprecedented opportunities in employment, education, health care, entrepreneurship, and civic participation* that digital inclusion will bring.

Our proposal, that intervention should start by ensuring that Scotland develops interconnected fiber backbone networks to ensure availability of backhaul, corresponds to the Recovery Act focus on *investments in "middle mile"* networks. Like this report, it argues that investment in backbone connections will have the effect of *encouraging private service providers to build connections to homes and businesses.*

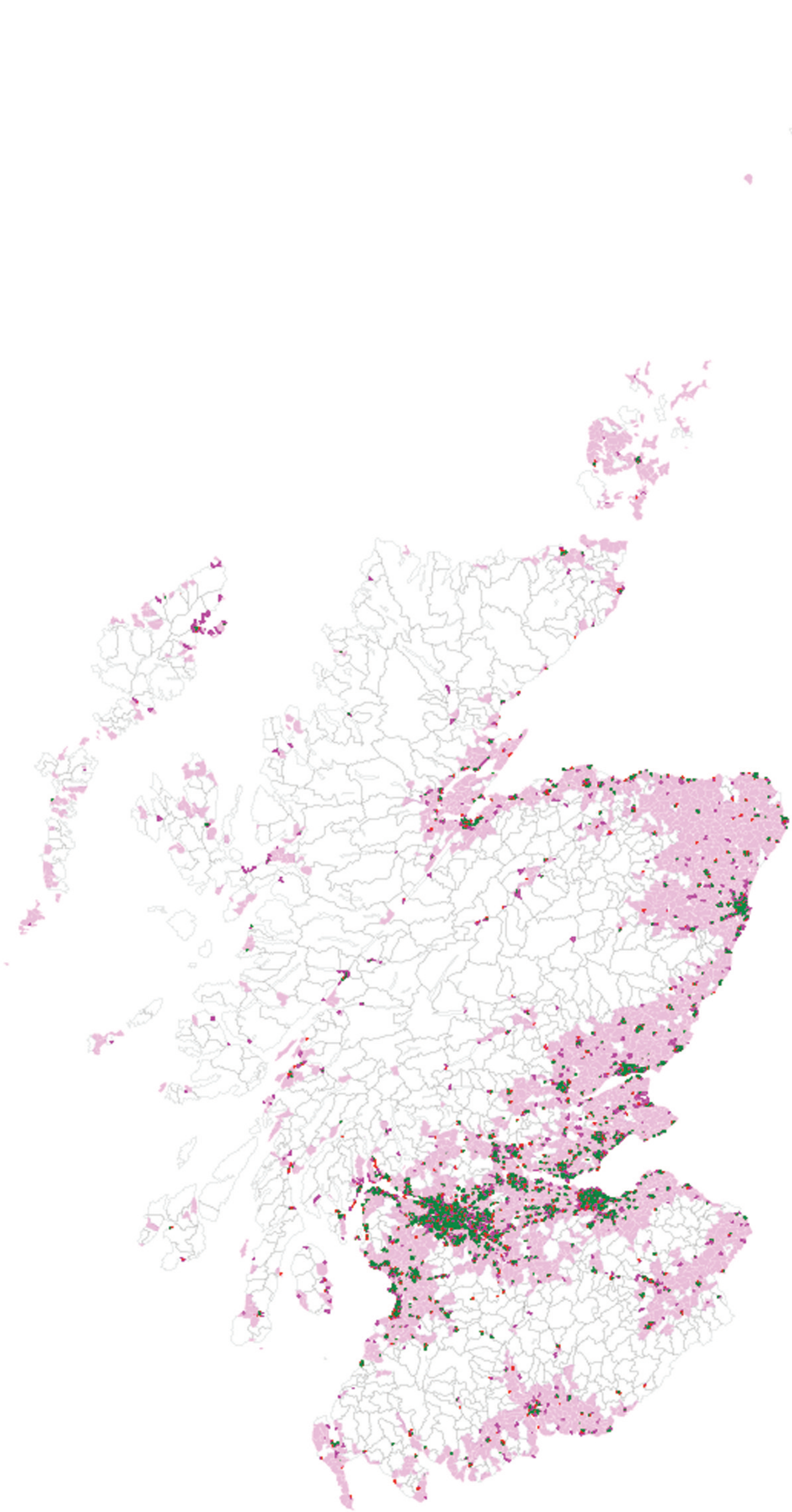
On the demand side, it argues that connecting *schools, libraries, and hospitals* will help to improve the *quality of their services and expose new users to broadband opportunities at work, school, and other venues.*

Funding for public computer centers, including those in urban and suburban areas, will promote digital literacy among the new generation of workers through one-time investments in equipment, hardware and software, and basic training.

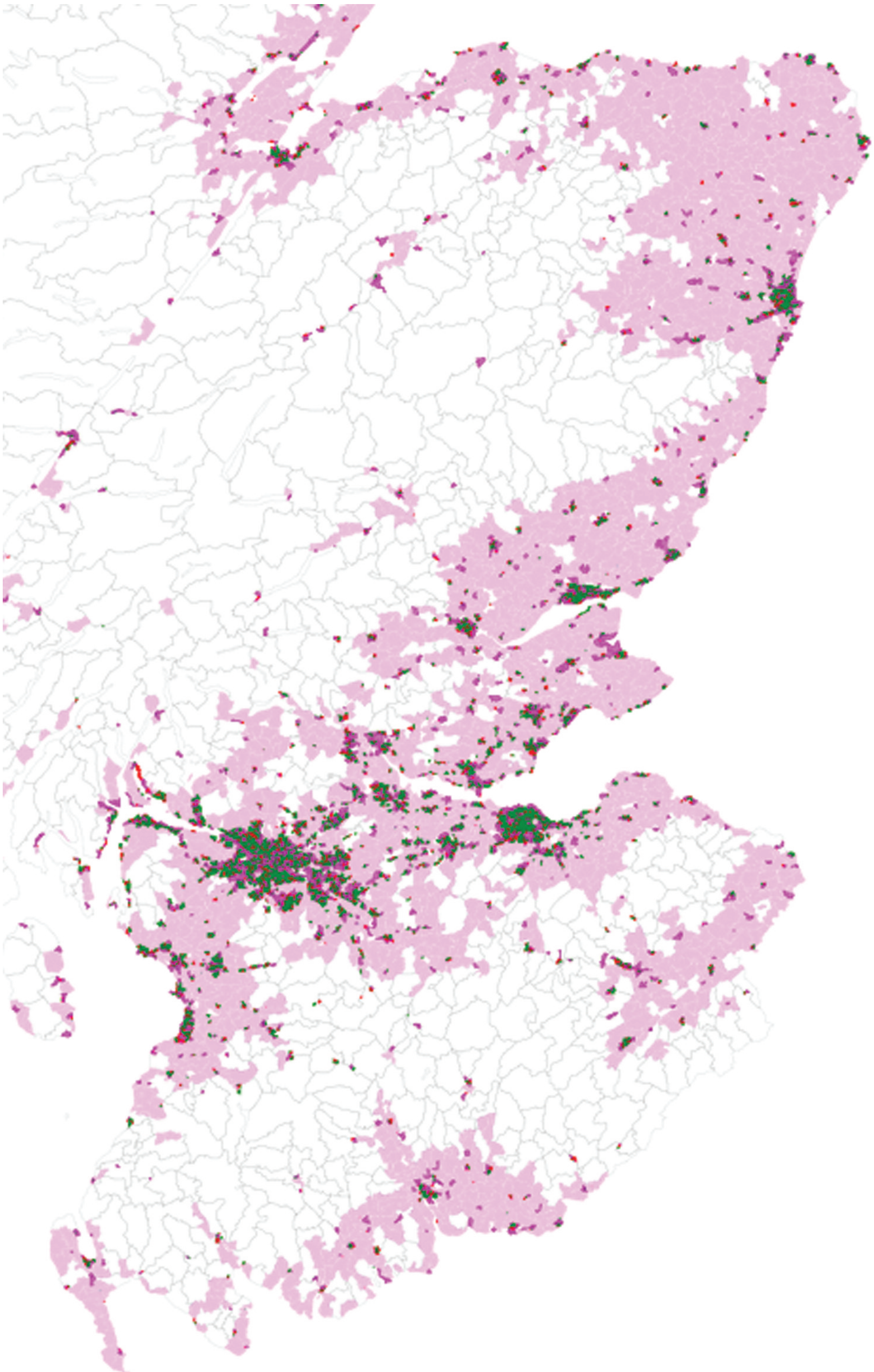
The Rutland and Tegola projects give two examples of the kind of local innovation that could be opened up by enabling local networks to have reasonably-priced access to backhaul. The Rutland experience was that, despite supportive regulation, it took Ofcom intervention to establish backhaul access for their project. The Tegola project has not yet overcome similar obstacles. We hope that the outcome of the Ofcom review of Wholesale Local Access and Wholesale Broadband Access, due to report in autumn 2010, will create a more transparent market in this area.

Currently, the five European countries with the highest penetration are Lithuania, Sweden, Norway, Slovenia and Estonia.

43 Does strategy matter? A comparison of broadband rollout policies in Finland and Sweden.



purple	7 – 70	p/km^2
purple	70 – 1000	p/km^2
red	1000-2000	p/km^2
green	> 2000	p/km^2



Dumfries to Inverness

purple	7 – 70	p/km^2
purple	70 – 1000	p/km^2
red	1000-2000	p/km^2
green	> 2000	p/km^2

7 Recommendations

Current estimates are that purely market-driven broadband rollout in Scotland will leave over 35% of population behind in NGA rollout, without mitigating action. Geographically, most of Scotland is without 2G coverage and local loop unbundling; 3G coverage is even sparser. Broadband uptake in Glasgow stands at 39%.[44]

Meanwhile, there is unmet demand for broadband access from rural communities, and, in some places, unused capacity that could, technically, meet this demand. Existing providers are unwilling to extend networks to small, distant communities. New entrants are unable to purchase backhaul.

Regulation of the communications industry is a reserved power. However, some devolved powers of the Scottish Government can contribute to the development of the digital society in Scotland. Effective dialogue and co-operation between the Governments, and with providers, large and small, is required.

Ofcom will also be an essential partner in such discussions, because it has power to regulate areas such as competitive access and spectrum. For example, current regulations on the use of unlicensed spectrum do not take account of the differing needs of sparsely and densely populated areas, and much of the licensed spectrum is unused, but unavailable, in parts of rural Scotland.

Potential policies for intervention include:

Supply

- remove fiscal, regulatory and competitive barriers to deployment and use;
- include communications infrastructure in public works and new build through policy and planning;
- make spectrum available for next generation wireless data applications, by extending unlicensed spectrum, and opening up unexploited 'whitespace';
- target direct funding for backhaul provision and community access in some high-cost areas;
- increase transparency through data collection and publication.

Demand

- foster tele-work, tele-medicine, e-government and e-learning through public procurement of open, standards-based systems;
- enable value creation through open data policies;
- support libraries to offer content as online loans;
- ensure public access within communities;
- develop digital literacy for all;
- ensure online availability of broadcast content.

We suggest the following as initial proposals for discussion and refinement. The technical proposals for broadband delivery are merely a first outline that will certainly need to be revised in the light of detailed local studies. In the end, this is a problem of engineering and economics.

44 http://www.ofcom.org.uk/research/cm/cmrnr09/scotland/cmrnrscot.pdf

The supply and uptake of new information and communications technology will be primarily market-driven. Business and residential customers will acquire their subscription connection at their own expense from a provider of their choice. However, the provision of end-user connections depends crucially on the availability of "backhaul" — a high-speed backbone network with international connections. The planning and development of this backbone network should be a strategic priority. The delivery of backhaul to the small scattered communities of the highlands and islands will pose particular challenges, but it must be done.

Forward planning and cooperation among the various parties that maintain national networks (including transport, power, water, and drainage) could significantly reduce the investment required. It is estimated that excavation accounts for 80% of the cost of laying trunk fiber. Fiber ducting can be installed at almost negligible marginal cost in conjunction with other works. The cost to deploy optical fiber ducts is less than €4 per metre if this duct is deployed together with other land work — this can cut the deployment cost by a factor of two to four times in rural areas and up to 10 times in dense cities. The EU FTTH business guide provides further information on costs.[45]

Fibers can be, literally, blown through the ducts at a later stage without further excavation. A transparent inventory of Scotland's core digital infrastructure would enable such forward planning.

Planning regulations should also be used to ensure that installation of ducting suitable for fiber to the end-user is incorporated in all new residential and business developments, as well as civil works. Regulation is also required to ensure wayleaves across potential "ransom strips" for telecommunications ducting, as is done for other utilities such as water and power.

In some areas, the core physical infrastructure already exists. In many areas the sewer network provides ideal routes for fiber cables. Increased cooperation and transparency and competitive access to the ducts and nodes of this infrastructure are required to enable the development of local access solutions. Opening up a wholesale market to allow competition and innovation in local access networks will extend the reach of the internet in Scotland and generate increased demand and uptake.

It has already been demonstrated that access to high-bandwidth backhaul can stimulate local innovation and community broadband initiatives in areas where provision of standard offerings is not economic. A backhaul infrastructure is also a necessary enabler for the provision of mobile wireless services in all areas.

When setting infrastructure requirements, particular attention must be paid to the evolution of rural tele-communications. Both needs and benefits may be higher in rural areas due to long distances and the remoteness of services. Internet access may be particularly useful in rural areas, for example, for the remote delivery of healthcare and education, and to provide online access to broadcast material in areas not served by wireless transmission. Businesses in remote areas will make more use of multimedia teleconferencing, to access and interact with global markets and services.

Universal access could be achieved in Scotland by a combination of FTTC (fiber to the cabinet) in built up areas, with sparser fiber provision supplemented by wireless distribution to all areas with population density above 70 p/km^2. For sparsely populated areas (say < 1000 inhabitants/km^2) wireless distribution can provide efficient access from backhaul within 30 km or more. For more concentrated communities, fixed connections will be required, to backhaul within 2 km, unless fiber is used for backhaul.

All communities should provide open internet access in supportive environments such as libraries and community centres to ensure universal access. Access to the backhaul network should be open to provide transit or peering arrangements to competing providers of mobile (3G, 4G) and fixed-line services.

45 http://www.ftthcouncil.eu/documents/studies/FTTH-Business-Guide-v1.1.pdf

Interim recommendations for a Digital Scotland strategy

7.1 Goals

- Scotland should plan for a communications infrastructure that includes an integrated fiber backbone accessible to all communities in Scotland.
- To maintain a competitive infrastructure Scotland should plan to deliver universal domestic access at a required bandwidth of 16 Mb/s by 2015, growing to 128 Mb/s by 2020, at contention ratios no greater than 20:1. These should be established as minimum requirements. Provision in new installations and advanced urban areas is expected to be at least five years ahead of this curve (128 Mb/s in 2015; 1 Gb/s in 2020).
- To enable such services, fiber backhaul should be available within reach of every accessible community in Scotland. Generally, fiber connection should be available within 2 km to allow fixed connections. For communities of less than a thousand inhabitants, or so, wireless connections to backhaul may provide the required bandwidth.
- In every community there should be public access in a supportive environment available and accessible to those without personal connection.

7.2 Recommendations

To achieve these goals, relevant bodies in Scotland should:

- **remove fiscal and regulatory obstacles**
  - Fiber infrastructure opened to internet traffic from all providers should be derated.
  - Work with Ofcom to ensure that regulation of licensed and unlicensed spectrum is adjusted to cater for optimal use in both rural and urban settings.
- **enable competition and collaboration**
  - Work with Ofcom and providers to ensure that optimal use is made of existing backbone infrastructure, linking existing providers and enabling new additions.
  - Work with Ofcom to ensure that operators collaborate to deliver open access to backbone services.
  - Encourage and support innovation in local models for access networks in areas where UK national providers fail to deliver.
- **stimulate development**
  - Planning regulations should require the installation of ducting suitable for fiber as part of all public works and new build, with an appropriate regulatory framework to ensure open and competitive access.
  - Public procurement of standards-based, open source systems should be used to enable local providers to adapt and build on public investment.
  - Local and national government should ensure open access to public data.
  - Scotland should work with the UK Government to ensure that broadcasters make their content available online, so it is accessible to those not reached by wireless transmissions.

- **ensure universal access and digital inclusion**
  - Establish public access points in all communities suitable for all ages, with priority for provision in areas with least internet uptake, to enable universal access.[46]
  - Build education and training into existing programmes to ensure that all children and adults can access the full range of opportunities that digital society offers.
  - Target direct funding for backhaul provision and community access in some high-cost areas.

46 None of the so-called UK online centres is in Scotland.

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