A CONTRIBUTION TO THE BROADBAND COMMISSION

Satellite as an effective and compelling solution to overcome the digital divide

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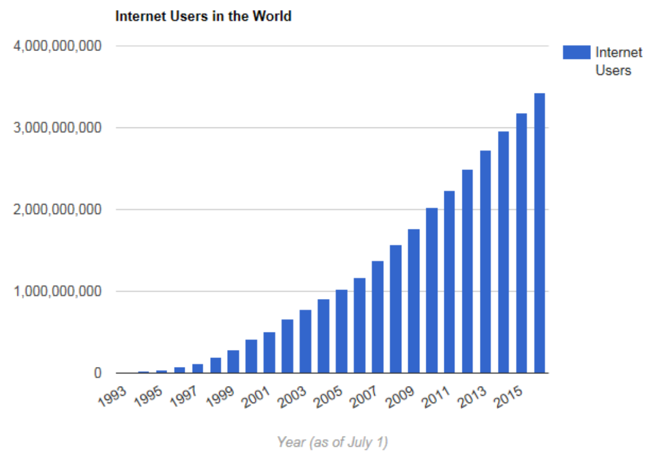
INTRODUCTION

Since its creation, the Broadband Commission has demonstrated the importance of broadband and information and communication technology (ICT) as a contributing factor to the realization of the UN goals. Today it remains committed to the necessity of promoting ICT as an accelerator of social, economic, and environmentally sustainable growth for all (Connect 2020 agenda for Global Telecommunication ICT Development). In the joint statement[1] made during the Special Session of the UN Broadband Commission for Sustainable Development at the World Economic Forum in Davos, leaders of government, industry, development and investment organizations from around the world recognized that global broadband connectivity is a significant enabler to achieve sustainable development for all and that Internet access, which is the backbone of today's knowledge, will accelerate the achievement of the United Nations 17 Sustainable Development Goals[2] (SDGs).

Access to broadband technologies has grown continually. According to a study by Internet Live Stats, "The first billion was reached in 2005, the second billion in 2010 and the third billion in 2014."[3] The graph below, from the same source demonstrates that the growth of Internet users in the world has been dramatic.

[1] Joint Statement: "Working together to provide Internet access to the next 1.5 billion by 2020": http://www.broadbandcommission.org/Documents/publications/davos-statement-jan2016-en.pdf
[2] For more information, visit the UN platform for Sustainable Development: http://www.un.org/sustainabledevelopment/
[3] See "Internet Users." At http://www.internetlivestats.com/internet-users/

Figure 1: Number of Global Internet Users per Year since 1993[4]



According to the latest International Telecommunications Union (ITU) "Measuring the Information Society Report"[5], 3.2 billion people are now online, representing 43.4% of the global population, but growth in Internet usage is slow. 167 economies included in the ITU's ICT Development Index (IDI) improved their IDI values between 2010 and 2015, proving that levels of ICT access, use and skills continue to improve all around the world. This ITU report emphasizes the need for more action to ensure that at least 50% of households in developing countries and 15% of households in least developed countries (LDCs) have Internet access by 2020, since the ITU estimates that only 45% of households in developing countries and 11% of LDC households will have Internet access by that date.

The key factor driving the growth in broadband worldwide is the desire for economic progress, which in turn enables governments, institutions and businesses to address the concerns which gave rise to the SDGs. Broadband connectivity is a proven path to such progress, as it allows for exchange of knowledge on a scale that cannot be achieved by any other means. Specific factors can be highlighted in the synthesis made by the European Parliament think tank[6], which presents a very clear analysis of the benefits of broadband in the European Union. After demonstrating the technical characteristics of wireline and wireless technologies, from an economical and cost perspective, the study outlines the benefits

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[4] Ibid.
[5] http://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2015/MISR2015-w5.pdf
[6] Broadband infrastructure: Supporting the digital economy in the European Union: http://www.europarl.europa.eu/RegData/etudes/IDAN/2015/565891/EPRS_IDA(2015)565891_EN.pdf

generated by the deployment of broadband. In short, broadband increases employment, spurs economic growth and acts as an accelerator to social inclusion. The 2012 ITU report[7], whilst acknowledging the challenges faced by the researchers at the time and the lack of disaggregated data which would provide the proper conditions for which the economic impact of broadband could be established, provided real and in depth evidence that broadband has considerable positive spill-over effects on the economy, both in terms of fostering growth and creating employment. In the discussion paper "Working Together to Connect the World by 2020"[8] more than 200 studies were conducted to examine the impact of broadband from macro and microeconomic to investment and connectivity perspectives. In the "Broadband Policy Briefing Paper" produced by Analysys Mason in September 2015 for the Broadband Commission[9], several tools are presented to outline the factors enabling broadband development with a synthesis of types of policies and measures that governments and national regulatory authorities can adopt to foster broadband roll-out i.e. the creation of a clear and stable regulatory framework and emphasis on the value of increased collaboration between regulators and broadband suppliers. The analysis further presents measures aimed at enhancing the demand side, to facilitate the use of broadband by the largest possible number of citizens and by fostering their interests for ICT.

Connecting the unconnected, together with the challenges of the SDGs, enables the building of a more inclusive and cohesive society. Specifically, connectivity must be brought to remote and rural areas, which have a strong correlation with regions of low broadband penetration, so that no one is left behind.

Broadband can be found virtually everywhere in metropolitan and urban areas of developed countries, where fiber and cable services are well-established. Unfortunately, access to these technologies is limited or non-existent in many parts of the world, in particular in developing countries and sparsely populated rural areas. Today, nearly one-half of the world's population lives in rural, hard to reach areas and satellite technology is uniquely placed for the delivery of broadband services in those areas.

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[7] Impact of Broadband on the Economy: https://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_Impact-of-Broadband-on-the-Economy.pdf

[8] Discussion paper for the Special Session at the Davos Forum: http://www.broadbandcommission.org/events/Pages/WEF-davos-2016.aspx

[9] Broadband Policy Briefing Paper 2015: http://www.broadbandcommission.org/Documents/publications/bb-Analysys-Mason-policy-briefing-paper-2015.pdf

As stated in the 2015 State of Broadband Report, the latest advances in satellite technology are playing a key role in helping deliver broadband to rural and isolated areas.[10] Satellites have huge reach over massive areas, enabling the immediate connection of many subscribers to broadband and Internet backbone networks in a single operation, rather than point-by-point roll-out. Coverage is instantaneous, systems are viewed as a flexible medium for last-mile technologies, access is available at any location within the satellite footprint and service quality is independent of geographical constraints. The ITU World Radiocommunication Conference (WRC-15) in November 2015 Members recognized the importance of the inherent sustainable, efficient and affordable characteristics of satellite systems by safeguarding spectrum needed for deploying broad band satellite networks. Increasingly, satellite broad band providers have developed powerful high speed networks comparable to cable and fiber.[11] Across both developed and developing counties satellite technology is a valuable solution to provide broadband access to less populated areas. Satellite solutions are also diverse, in addition to high-capacity fixed broadband applications, of competitive speed and quality to fiber, satellites are essential in challenging topographies, on water, and in the skies, where terrestrial technologies are ineffective; moreover, satellite technologies can provide seamless mobility in a small form factor enabling a range of mobile, machine-to-machine and other applications promoting development.

The aim of this paper is to show the relationship between the unconnected and rural and remote regions, as well as describing how, more than ever before, satellite systems provide an effective and affordable solution for connecting broadband provides Internet access for people living in these areas. For many of these populations, satellite provides the only viable option and, unlike terrestrial solutions, requires no additional investment in infrastructure.

The paper outlines financing considerations for implementing satellite broadband to reach universal connectivity, comparing investment requirements for satellite broadband with the investment required for other technologies and identifying various models for funding.

[10] http://www.broadbandcommission.org/documents/reports/bb-annualreport2015.pdf
[11] http://satellite-internet-review.toptenreviews.com/

SOLUTIONS FOR CONNECTIVITY: THE CASE FOR SATELLITE BROADBAND FOR REMOTE AND RURAL POPULATIONS

According to the 2015 State of Broadband report, 43.4% of the world's population lacks access to the Internet and is unable to take advantage of the economic and social benefits that the Internet has to offer.[12] The table below depicts data from Internet Live Stats[13] and shows the percentage of population with access to broadband infrastructure, giving us an idea of where the large offline populations are located.

Percentage of Population with Access to Broadband Infrastructure [14]	
0-10%	Afghanistan, Benin, Burundi, Central, African Republic Chad, Congo, Comoros, DR Congo, Eritrea, Ethiopia, Guinea, Guinea-Bissau, Liberia, Madagascar, Malawi, Mozambique, Myanmar, Niger, Sierra Leone, Somalia, Tanzania, Timor Leste, Togo
10-25%	Algeria, Angola, Bangladesh, Botswana, Burkina Faso, Cambodia, Cameroon, Côte d'Ivoire, Djibouti, Equatorial Guinea, Gabon, Gambia, Haiti, Honduras, Iraq, Indonesia, Kiribati, Laos, Lesotho, Libya Mali, Marshall Islands, Mauritania, Namibia, Nepal, Nicaragua, Papua New Guinea, Uganda, Rwanda, Senegal, South Sudan, Tajikistan, Turkmenistan, Yemen, Zambia, Zimbabwe.
25%-40%	Bhutan, Cuba, Egypt, El Salvador, Ghana, Grenada, Guatemala, Guyana, India, Kyrgyzstan, Micronesia, Mongolia, Samoa, São Tome and Principe, Sri Lanka, Sudan, Swaziland, Syria, Vanuatu.
40%-60%	Armenia, Belize, Bolivia, Bulgaria, China, Colombia, Costa Rica, Ecuador, Dominican Republic, Fiji, Georgia, Jamaica, Jordan, Kazakhstan, Kenya, Maldives, Mauritius, Mexico, Moldova, Morocco, Nigeria, Panama, Paraguay, Romania, Saint Lucia, Serbia, Seychelles, South Africa, Surinam, Thailand, Turkey, Tunisia, Ukraine, U.S. Virgin Islands, Uzbekistan, Venezuela, Vietnam.
60%-80%	Albania, Antigua and Barbuda, Argentina, Azerbaijan, Belarus, Bosnia and Herzegovina, Brazil, Brunei, Cayman Islands, Chile, Croatia, Cyprus, Dominica, French Polynesia, Greece, Greenland, Hong Kong, Italy, Israel, Latvia, Lebanon, Lithuania, Macedonia TFYR, Malaysia, Malta, Montenegro, New Caledonia, Oman, Poland, Portugal, Russia, St. Kitts and Nevis, St. Vincent and the Grenadines, Saudi Arabia, Slovenia, State of Palestine, Trinidad and Tobago, Uruguay
80%-100%	Andorra, Australia, Austria, Aruba, Bahamas, Bahrain, Barbados, Belgium, Bermuda, Canada, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Hungary, Iceland, Ireland, Japan, Liechtenstein, Luxemburg, Monaco, Netherlands, New Zealand, Norway, Puerto Rico, Qatar, Singapore, Slovakia, South Korea, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States

[12] "The State of Broadband 2015 Report", page 56, http://www.broadbandcommission.org/documents/reports/bb-annualreport2015.pdf

[13] An online database that compiles information from the ITU, the World Bank, the U.N. Department of Economic and Social affairs as well as the U.S. Central Intelligence Agency

[14] ITSO generated table based on data from Internet Live Stats. http://www.internetlivestats.com/internet-users-by-country/ . The complete set of data can be found in Annex 1.

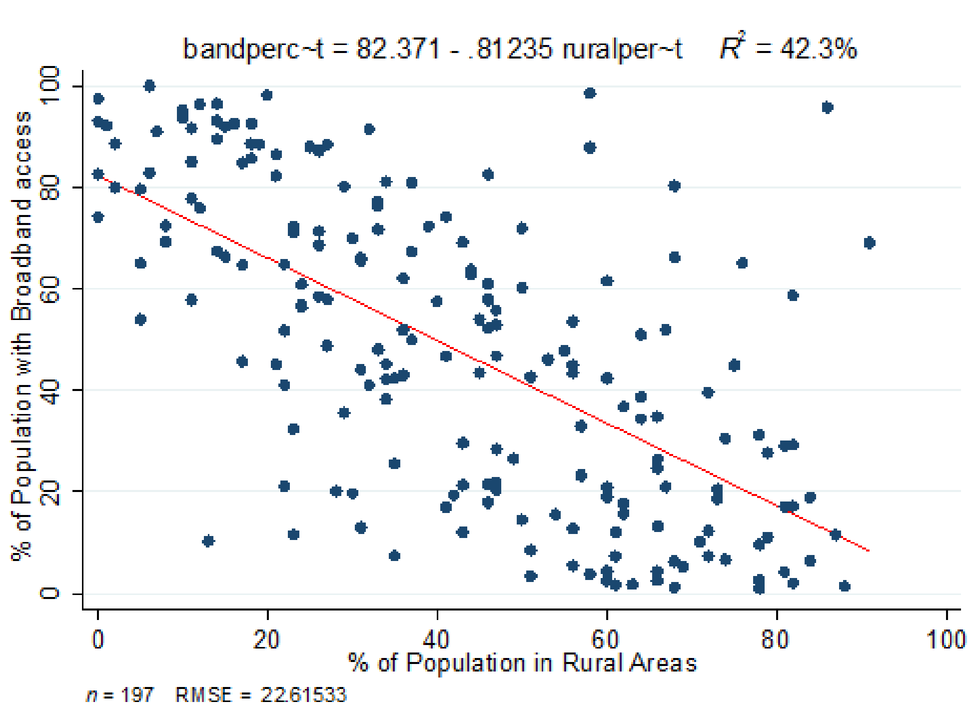
In addition, the ITU's "Measuring the Information Society Report 2015" estimates that over 70% of people who do not have access to a broadband infrastructure are in rural areas[15] and, according to the World Economic Forum's "Global Information Technology Report 2015"there is a huge divide between the well-connected urban centers and off-the-grid rural areas.[16] The table below, based on data from the World Bank, shows where the largest percentage of population living in rural areas is located.

	Percentage of Population Living in Rural Areas[17]
100%-80%	Burundi, Ethiopia, Liechtenstein, Malawi, Nepal, Niger, Papua New Guinea, Saint Lucia, Samoa, South Sudan, Sri Lanka, Trinidad and Tobago, Uganda.
80%-60%	Antigua and Barbuda, Bangladesh, Barbados, Bhutan, Burkina Faso, Cambodia, Chad, Comoros, Eritrea, Grenada, Guinea, Guyana, India, Kenya, Kyrgyzstan, Laos, Lesotho, Madagascar, Mali, Micronesia, Mozambique, Myanmar, Pakistan, Rwanda, St. Kitts and Nevis, Solomon Islands, Somalia, Sudan, Swaziland, Uzbekistan, Tajikistan, Tanzania, Timor Leste, Togo, Vanuatu Vietnam, Yemen, Zimbabwe
60%-40%	Albania, Angola, Aruba, Azerbaijan, Belize, Benin, Bosnia and Herzegovina, Botswana, Cameroon, Central African Republic China, Cote D'Ivoire, Croatia, DR Congo, Egypt, Equatorial Guinea, Faeroe Islands, Fiji, French Polynesia, Gambia, Georgia, Ghana, Guinea-Bissau, Guatemala, Haiti, Honduras, Indonesia, Jamaica, Kazakhstan, Kiribati, Liberia, Macedonia, Maldives, Mauritania, Mauritius, Moldova, Namibia, Nicaragua, Nigeria, Paraguay, Philippines, Romania, St, Vincent and Grenadines Senegal, Serbia, Seychelles, Sierra Leone, Slovakia, Slovenia, Syria, Thailand, Turkmenistan, Zambia
40%-20%	Algeria, Armenia, Austria, Belarus, Bolivia, Bulgaria, Brunei, Cabo Verde, Colombia, Congo, Costa Rica, Cuba, Cyprus, Czech Republic, Djibouti, Dominica, Dominican Republic, Ecuador, El Salvador, Estonia, France, Germany, Greece, Hungary, Iran, Iraq, Ireland, Italy, Latvia, Libya, Lithuania, Malaysia, Marshal Islands, Mexico, Mongolia, Montenegro, Morocco, New Caledonia, Panama, Peru, Poland, Portugal, Romania, Sao Tome and Principe, Spain, South Africa, Surinam, Turkey, Tunisia, Ukraine, U.S. Virgin Islands, Uzbekistan, Vietnam.
20%-0%	Andorra, Argentina, Australia, Bahamas, Bahrain, Belgium, Bermuda, Brazil, Canada, Cayman Islands, Chile, Croatia, Denmark, Finland, Gabon, Greenland, Hong Kong, Iceland, Israel, Japan, Jordan, Kuwait, Lebanon, Luxemburg, Malta, Monaco, Netherlands, New Zealand, Norway, Oman, Puerto Rico, Qatar, Russia, Saudi Arabia, Singapore, South Korea, Sweden, United Arab Emirates, United Kingdom, United States, U.S Virgin Islands, Uruguay, Venezuela

[15] "ITU Measuring the Information Society Report 2015" http://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2015/MISR2015-w5.pdf
[16] "World Economic Forum's 2015 Global Information Technology Report" http://www3.weforum.org/docs/WEF_Global_IT_Report_2015.pdf
[17] ITSO generated table based on data from the World Bank. http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS. The complete set of data can be found in Annex 2.

In this context, using the data from the Internet Live Stats on percentage of population with broadband access and data from the World Bank on percentage of population in rural areas, the scatter graph below depicts a strong negative correlation between access to broadband infrastructure and the percentage of population living in rural areas (i.e. as the percentage of population living in rural areas increases, the percentage of population with access to broadband infrastructure decreases). However, this only demonstrates correlation and not causality since there are other factors that influence the availability of broadband technologies such as GDP per capita, market competition, and regulatory environment, among others.

Figure 2: Access to Broadband Infrastructure in Urban and Rural Regions[18]



By using the same sources, the maps below give a clear picture of where the large offline populations are located. The first map shows the percentage of the population that has access to broadband infrastructure.[19] The second map shows the percentage of the population that lives in rural regions. Lastly, the third map is a composite of the first two maps and it shows the countries that fit the pattern of having low access to broadband (less than 60% of the population can access it) and high rural populations (more than 40% of the population).

[18] ITSO generated graph based on data from Internet Live Stats. http://www.internetlivestats.com/internet-users-by-country/
[19] Refers to either a fixed (wired) or mobile network: analogue dial-up modem via standard telephone line, ISDN (Integrated Services Digital Network), DSL (Digital Subscriber Line) or ADSL, Cable modem, High speed leased lines, Fiber, Powerline, Satellite broadband network, WiMAX, Fixed CDMA, Mobile broadband network (3G, e.g. UMTS) via a handset or card, Integrated SIM card in a computer, or USB modem

Figure 3: Access to Broadband Infrastructure[20]

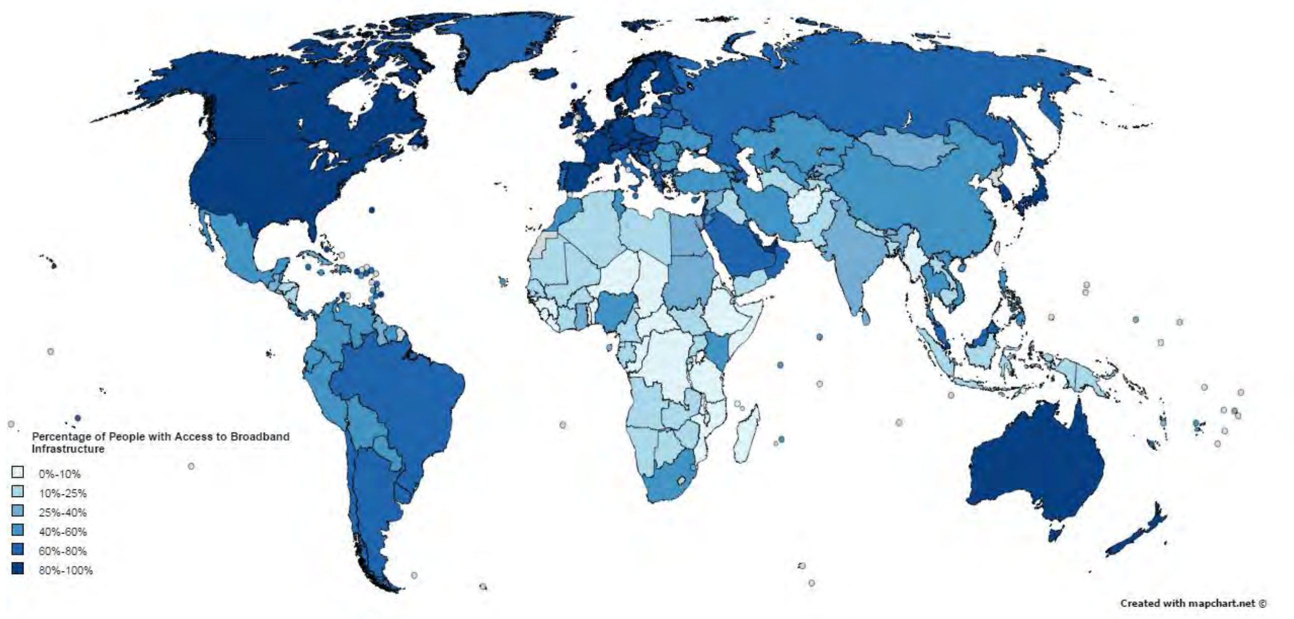
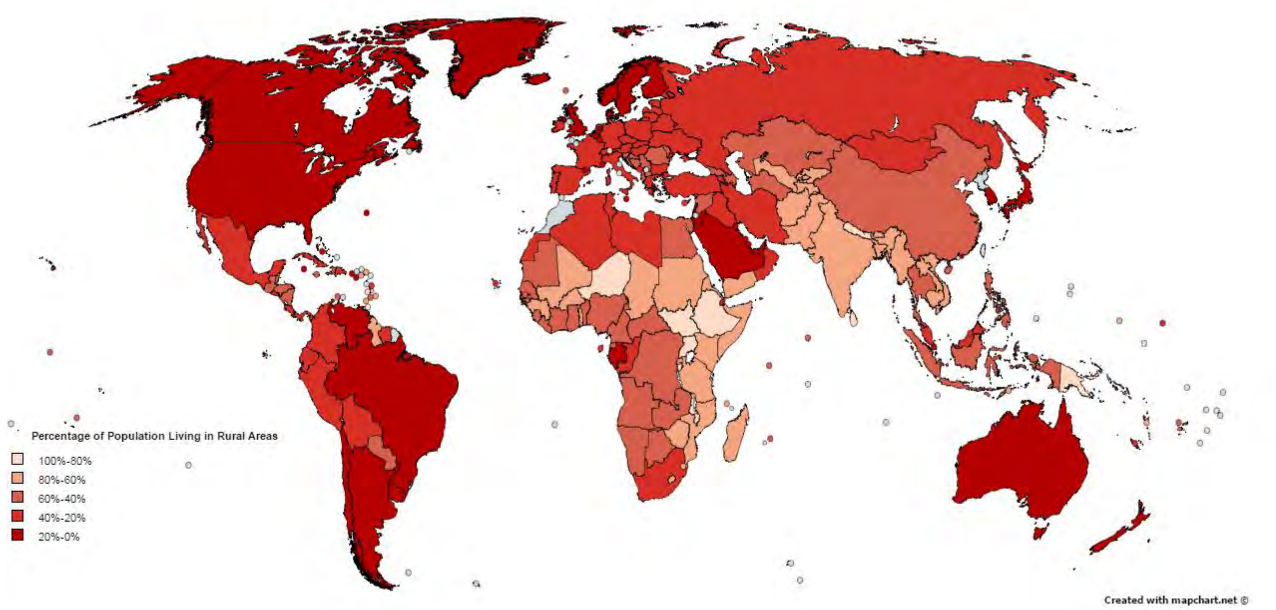


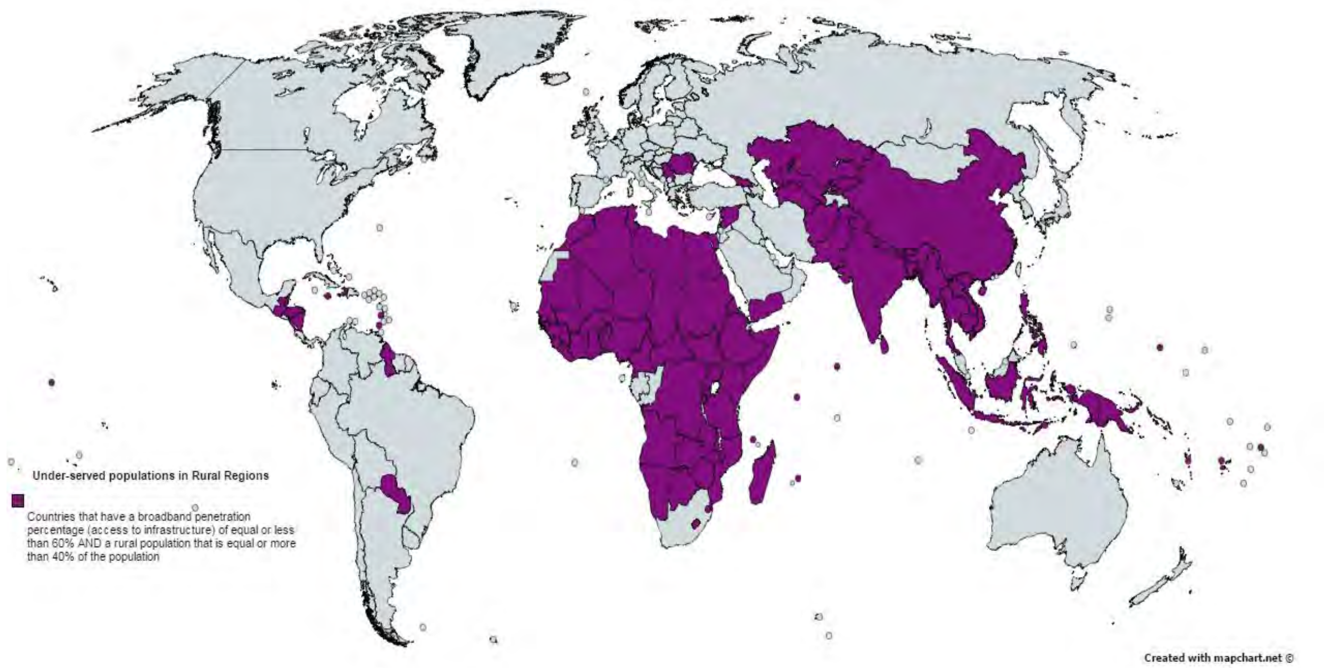
Figure 4: Rural Population Percentage by Country[21]



[20] ITSO generated map based on data from Internet Live Stats for 2016. http://www.internetlivestats.com/internet-users-by-country/

[21] ITSO generated map based on data from the World Bank for 2014. http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS

Figure 5: Countries with Low Access to Broadband Infrastructure and Large Rural Populations[22]



From the above, it is clear that broadband access is still a challenge faced by many, particularly those living in rural areas or areas with low population densities. Therefore, it is essential to address this problem and find a feasible way to connect the unconnected as a matter of urgency.

There are three main technologies for broadband infrastructure: fiber optic cables; telecommunications satellites and terrestrial microwave systems. Each technology has its own strengths and limitations and the choice of a particular technology will depend on many factors. When trying to find the best combination of technologies to lead to the most effective technical and financial solution, it is essential to take into account the population density of the region that is considering establishing broadband infrastructure. For instance, fiber optic cable tends to be the preferred media in densely populated areas because of its transmission capacity and cost effectiveness in these cases. However, in rural areas or areas with low population densities, where there are still many without access to the Internet, this argument reverses, and satellite broadband becomes the preferred solution.

[22] ITSO generated map based on data from the previous two sources. A full list of countries and complete set of data can be found in Annex 3.

In addition, in developing countries, where terrestrial technology has not reached the same level of penetration, satellite is in some cases the only available option. Nevertheless, satellite technology is also important in developed countries, which often designate satellite broadband in their national broadband strategies as a solution for rural areas or areas with low population densities.[23]

Two key attributes of satellite technology, when compared to terrestrial, are its universality and its reliability. Satellite operators have put in place an infrastructure that already covers the whole world. Satellite is the only broadband technology that provides full coverage, in metropolitan as well as in rural or most remote areas, including mountainous regions, islands, the seas and the skies. Satellite broadband connections can be set up immediately without large investment in terrestrial infrastructure. With only a modem, an antenna and electricity, satellite broadband access is available at any location in the satellite coverage area and the service quality is independent of geographical factors.[24] The broad reach of satellite systems also ensures interoperability among diverse constituencies and across borders.

Satellite technology's reliability ensures that mission critical services- such as emergency aid and first response, smart assets, utility networks, transportation systems, border control and security, etc.-function all the time regardless of adverse circumstances. This is why satellite broadband becomes crucial in cases of natural disasters or other humanitarian needs when terrestrial infrastructures may be not available, in order to coordinate crisis management and work in the field units. As such, satellite broadband should be regarded as part of a country's critical national infrastructure.

Another important characteristic of satellite technology is that satellites are point-to-multipoint systems, which means that they do not end at a single, specific point, but can reach all geographic targets within a given area. As a result, it is possible to provide instant satellite coverage over a region and satellite broadband can be the solution for rural and remote areas.

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[23] See examples of the US, Australia and the European Union on page 14.
[24] Analysis Mason and Intelsat. "Taking Mobile to Rural Africa." Microwave Journal available at http://www.microwavejournal.com/ext/resources/BGDownload/f/4/6069-Hybrid-Backhaul.pdf?1326826607

Moreover, it is important to reconsider old assumptions about the performance of satellite in providing broadband services. Satellite broadband has vastly improved in terms of quality and the speed/capacity of the latest systems is comparable to or better than some fixed/residential broadband systems in Europe or in the United States. Indeed, the technology of satellite systems is evolving. For example, a new concept for geostationary satellites, called High Throughput Satellites (HTS), has recently been developed in particular for broadband services. Most of the major satellite operators are presently already operating, or are planning the launch of HTS satellites.

Satellite technology is essential to connect communities in rural, remote and low population density areas. By providing broadband connectivity to rural and remote areas, satellite technology also contributes to economic growth, notably for small and medium businesses in those areas.

Terrestrial technologies, like fiber optic cables, require considerable investments in infrastructure that will not be economically feasible in regions of low population density. Therefore, satellite broadband plays a crucial role in connecting rural and low population density areas, where terrestrial broadband is not cost effective.

There have been several developments of satellite broadband that will prove useful in connecting rural and remote regions. For example:

- African mobile communications company Vodacom has partnered with Intelsat to extend service to over 700 rural sites in the Democratic Republic of Congo, and has done so profitably with a cost-effective, quickly deployable solution that has given them a first-to-market advantage.[25]
- Inmarsat partnered with Turksat, the Turkish state-owned satellite operator to broaden coverage in the region. Turksat can now offer a significantly larger amount of mobile satellite products and services to its customers in Turkey, the Middle East, Africa, the Caucasus and Central Asia. Also Inmarsat will be able to offer Turksat satellite services to its customers in the region.[26]

[25] http://www.intelsat.com/wp-content/uploads/2016/03/Delivering-rural-cellular-services-in-DRC-Vodacom-7251-CS.pdf
[26] http://www.inmarsat.com/press-release/inmarsat-turksat-form-strategic-partnership-extend-availability-mobile-satellite-services-turkey-mea-caucuses-central-asia/

- Eutelsat and Facebook are teaming up to leverage satellite technologies to get more Africans online. Under a multi-year agreement with Spacecom, the two companies will utilize the entire broadband payload on the future AMOS-satellite to be launched in 2016, and Eutelsat will further develop its own capacities for Africa with a High Throughput Satellite system ordered in October 2015.[27]

These satellite broadband services can help meet diverse governmental objectives and create platforms for sustainable development in diverse industrial sectors. A few examples are highlighted below.

Government Applications:

- **Smart City/Smart Society –** Satellite connectivity can drive development of smart city/smart society applications that integrate various technologies to assist in the management of a community's assets, connect citizens to their government, and improve overall quality of life. Connected sensors can be used to manage electricity distribution, monitor pollution, ensure security, and improve the efficiency of public services ranging from water filtration, waste management, public transportation, street lighting, and public education.
- **eLearning/mLearning –** Satellite communications can bring educational resources and Internet connectivity to drive educational initiatives in remote and highly vulnerable communities. Satellite-connected mobile learning centers can ensure that even children in refugee camps, displaced by events outside their control, can continue to have access to educational resources and a connection to the rest of the world.
- **Telemedicine/eHealth –** Portable satellite broadband services power crucial connectivity to allow specialist doctors to remotely monitor the health of patients in villages and flag early detections of conditions such as diabetes, hypothermia and high blood pressure. For example, satellite mobile broadband services bring ultrasound technology and expert support to isolated communities, allowing them to obtain medical help without the need for a long and difficult journey.

[27] http://news.eutelsat.com/pressreleases/eutelsat-and-facebook-to-partner-on-satellite-initiative-to-get-more-africans-online-1228638

- **Environment –** Satellite services, especially small form factor mobile satellite devices, help capture critical data on climate change and other environmental changes. Through sensors tracking environmental changes, connectivity to researchers in remote areas, and buoy systems monitoring movements of sharks and other sea life, satellite solutions help both developed and developing communities alike better understand the changing world.
- **Disaster Response –** Mobile and portable satellite communications are often the only connectivity options available in the critical hours and days immediately after a major disaster. While terrestrial facilities might be incapacitated for any number of reasons, relief workers, public safety, and military personnel rely upon satellite communications to save lives and reestablish order.

Industrial & Commercial Applications:

- **Machine-to-machine (M2M)/Internet of Things (IoT) –** Today both mobile and fixed assets require one and two-way connectivity between themselves and other assets. Reliable satellite networks are sometimes the only solution. In developing countries, this could range from remote monitoring and management of industrial equipment, to scientific/environmental sensors supporting disaster early warning systems, to anything in between.
- **Rural Economics** – Satellite connectivity gives isolated communities access to banking and financial services they might otherwise lack. From supporting the establishment of remote and temporary bank branches, to facilitate electronic point of sale systems and ATMs satellite services help promote an economically sustainable and connected community.
- **Oil/gas exploration –** Portable broadband terminals are ideal for exploration, such as individual geoscientists or small teams looking for new reserves. Connectivity is also essential to maintaining and monitoring infrastructure across wide areas, enabling certification engineers and inspectors travelling between remote installations and along pipelines to check for faults or report on repairs - to set up temporary communications.
- **Agriculture** – Satellite connectivity can help promote more effective and efficient food production. Satellite services support remote real-time monitoring of fields and hydroponic installations to maximize yield in harsh environments. Additionally,

broadband connectivity enables farmers to monitor pricing trends to determine the optimum time to bring their crops to market.

- **Sustainable fishing –** With a global drive towards conservation and marine sustainability, the fishing industry faces increasing pressure and stronger regulation. Robust and reliable satellite communications can help meet the commercial, regulatory and personal welfare requirements of fishermen and fishing fleets.
- **Smart shipping –** In addition to traditional satellite voice, data, and distress services that have been a mainstay of maritime communications for decades, mobile satellite broadband connectivity is enabling 'smart shipping' applications, including video conferencing, remote vessel assistance/diagnostics, telemedicine, video surveillance and information management systems for maritime 'big data' applications.

Furthermore, satellite technology must also be included in hybrid approaches and, in fact, many governments already incorporate hybrid approaches, which include satellite technology for rural, remote and low population density regions in their National Broadband Plans (NBPs). For example, the following countries directly consider satellite broadband in their connectivity regimes:

- The United States Federal Communications Commission's NBP includes the use of satellite technology to reach the 14 million Americans living in 7 million housing units that do not have access to terrestrial infrastructure.[28]
- The Kenyan Government's National Broadband Strategy directly identifies satellite as a viable option for broadband.[29]
- Brazil's NBP includes the GESAC Program which is a network of free broadband services via satellite for schools, community tele-centers and other public or community entities in areas not reached by terrestrial infrastructure.[30]
- Malaysia's NBP uses satellite, in addition to other technologies to meet its growing demand for broadband service. [31]
- The European Union's Digital Agenda for Europe provides for satellite connections in 28 countries to cover the three million people not covered by fixed and mobile broadband

[28] Chapter 8 of the FCC's National Broadband Plan, p. 136 available at http://www.broadband.gov/download-plan/
[29] http://www.ca.go.ke/index.php/national-broadband-strategy
[30] http://www.infodev.org/infodev-files/resource/InfodevDocuments_1128.pdf
[31] http://www.ictregulationtoolkit.org/en/toolkit/notes/PracticeNote/3138

networks.[32] Additionally, the European Commission's "5G Action Plan" is likely to formally include satellite broadband as a key enabler for the European Digital Single Market.

- Australia is developing an extended program of broadband delivery via satellite. The Australian National Broadband Network (NBN) will provide high-speed broadband access to all Australian homes and businesses through a mix of three technologies: optic fiber, fixed wireless and next-generation satellite.[33]

Satellite technology is uniquely able to deliver universal broadband access to rural and remote areas, since the infrastructure is already in place as most of the populated world is covered by existing satellites, so the only investment needed is for the local equipment and the cost of usage.[34] Unlike terrestrial technologies, with satellite technology, it is no more expensive to cover rural areas than urban ones.

Satellite is not just the right technology for rural and remote areas, it is also essential for providing connectivity in challenging environments where terrestrial solutions (both wired and wireless) often cannot perform effectively. For example, satellite technologies are the only way the reliably and efficiently deploy connectivity in the seas and the skies. Additionally, satellites are particularly useful in challenging geographies. This can include mountainous regions where line-of-sight communication in difficult, and harsh environments, such as areas subject to adverse weather, dust, wind, smog, extreme cold or hot temperatures, or other factors rendering terrestrial broadband solutions inoperable or unreliable.

While satellite is an essential mechanism for delivering universal broadband access, investment in these services can contribute to development above and beyond just fixed last-mile access and backhaul solutions, particularly by leveraging mobile satellite connectivity technologies.

Internet giants such as Google and Facebook have already realized the importance of satellite broadband to connect hard to reach communities. Last year, Google invested $900 million in SpaceX "to support continued innovation in areas of space transport, reusability and satellite

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32 http://europa.eu/rapid/press-release_IP-13-968_en.htm
33 http://www.nbn.gov.au/.
34 http://www.intelsat.com/intelsat-news/broadband-bridging-the-digital-divide/

manufacturing" and has expressed a special interest in an Internet delivery satellite".[35] SpaceX plans to launch 4,000 small, low-cost, disposable satellites into orbit.[36]

To close the infrastructure gap in rural and remote areas, it is essential to use satellite technology. This will require utilizing existing satellite systems and ensuring that sufficient protected spectrum is available to facilitate continued growth and innovation in the satellite industry. One challenge, however, is that although satellite infrastructure is in place, and growing, commercial service providers (of any type of technology) must seek a return on the substantial investment needed to deploy their systems. Therefore, it is necessary to bring the public and private sectors together, such as through government programs and partnerships that would prioritize the development of broadband solutions specifically directed to these areas.

[35] http://spacenews.com/google-spacex-investment-is-900-million/
[36] http://www.cnn.com/2015/10/30/tech/pioneers-google-facebook-spacex-oneweb-satellite-drone-balloon-internet/

FINANCING CONSIDERATIONS FOR IMPLEMENTING SATELLITE BROADBAND TO REACH UNIVERSAL CONNECTIVITY

From the above, we have seen that many are still unconnected and that satellite technology could be the solution for bringing connectivity to those, particularly to the ones in rural and remote areas. In this context, it is necessary to understand the financial considerations for implementing satellite broadband to reach universal connectivity. In other words, what it will cost and how much financing is needed to connect the next 1.5 billion people with Internet access. This section will also discuss the different methods of financing broadband networks such as central or local government funding, public private partnerships and commercial funding. In addition, this section will contextualize the required investment for satellite technology as compared to other technologies for broadband networks such as FTTH, LTE, and NGN,[37] and also the roles of governments, the private, sector and international organizations.

Numerous studies have been completed on the cost of broadband network deployment on a national or regional level. A recent ITU discussion paper submitted during the January 2016 special session of the Broadband Commission on Digital Development summarized several of these studies. Here are a few of the main findings of that report:[38]

- Analysis conducted by Pantelis Koutroumpis, in part for the European Investment Bank, concluded that the total cost of achieving broadband targets across Europe, would range between EUR 73 and 221 billion, with costs per household ranging between EUR 130 and 1,566. The analysis did not consider satellite or WiMAX solutions.[39]
- To create the broadband infrastructure needed to provide universal coverage, a paper produced for the World Bank's Africa Infrastructure Country Diagnostic determined an investment equivalent to 0.1 percent of GDP would be required through 2015—translating to US $6.0 billion for 24 African countries or an average of US $752.4 million per year from 2008 through 2015. The level of investment needed to cover the efficient market—commercially viable areas only—would be about three-quarters of the

[37] FTTH: Fiber to the home / LTE: Long term Evolution (Wireless communications of high speed data) / NGN: Next generation networks

[38]:ITU, *Working Together to Connect the World by 2020* (2016) *at* http://www.broadbandcommission.org/Documents/publications/davos-discussion-paper-jan2016.pdf. See Annex 4 for full table

[39] Koutroumpis "An assessment of the total investment requirement to reach the Digital Agenda broadband targets", Study for the European Investment Bank at http://point-topic.com/wp-content/uploads/2013/05/Point-Topic-Europes-superfast-broadband-investment-needs-20130520-1.2.pdf

universal-coverage level (US $4.5 billion, or US $564.5 annually, for the 24 countries). The paper concluded that this indicates a surplus funding need of US $1.5 billion to be met by governments.[40]

- In 2014, the World Bank performed a study for the Middle East and North Africa that found that the total investment to meet regional broadband targets was US$28-35 billion. The targets were to roll out 10 Mbps for 100 percent of population and 30 Mbps for 50 percent of population, using a combination of FTTC and LTE technologies.

Additional studies have discussed the total investment needed to boost already existing terrestrial broadband networks on a national level:

- South Africa invested US $332 million for electronic communications networks including the high capacity West African Cable System (WACS). This investment was through South Africa's state owned enterprise Broadband Infraco.[41]
- Kenya spent US $248,000 from 2004-2005 and US $28 million in 2006-2007 to build the National Optic Fiber Broadband Network. [42]
- New Zealand's government recently funded a US $1.03 billion project to boost its fiber networks.[43]
- In November of 2015, Brazil announced in its NBP an investment of US $3.97 billion to improve its existing broadband projects and create new projects.[44]

These studies and projects demonstrate that cost forecasts vary dramatically based on differences in the access technology assumptions, coverage targets, geography, and other aspects. Most of these studies assumed a fiber-optic or other wired broadband network as the predominant access technology for next generation networks, and therefore they show how costly these technologies can be to achieve broadband targets. Even where the analyses did consider satellite connectivity, the studies did not consider the full range of diverse services that can be provided by the latest generation of satellite technologies which can have a

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[40] "Africa Infrastructure Country Diagnostic" at http://www.eu-africa-infrastructure-tf.net/attachments/library/aicd-background-paper-3-ict-invst-summary-en.pdf

[41] "Investment Models and Regulatory Constrains in selected African Countries." https://www.researchgate.net/publication/263367928_Investment_models_and_regulatory_constraints_for_broadband_backbone_roll-out_in_selected_African_countries

[42] Ibid.

[43] ITU News "Growth, productivity, and the economy" at http://www.itu.int/net/itunews/issues/2011/05/14.aspx

[44] "Brazilian government to invest $4bi in broadband expansion." http://www.zdnet.com/article/brazilian-government-to-invest-4bn-in-broadband-expansion/

substantial impact on both achieving targets and keeping costs down. Compared to the high costs to conduct fiber and wireless deployments estimated by the analyses above, satellite broadband solutions can be a cost-effective way to provide connectivity to the unconnected in rural, remote, and low population density areas.

According to the 2014 Satellite Industry Association (SIA) "Satellites and Export Credit Financing Fact Sheet" report, communications satellite projects can range from US $300-$600 million, which is significantly less than the terrestrial technology projects described in Annex 4. This is just for the sake of comparison since the costs of satellite is born by the satellite operators and the cost of terrestrial infrastructure is often funded by governments. These figures include the spacecraft, launch, and launch insurance. Satellite deployment costs are typically high, up-front and fixed, and may have "unique risk factors, which are typically recouped over the expected 15-year lifetime of the satellite."[45]

Moreover, new satellite systems are challenging conventional assumptions about speed, capacity, and latency. Many operators have recently deployed or plan soon to deploy systems that can contribute to a solution to the problem of connecting the next 1.5 billion people around the world. While the deployment of a satellite system is a capital-intensive endeavor, satellite systems typically cover large geographic areas spanning multiple countries. Thus the deployment cost of a satellite system can be considered as spread across a region. With all of this taken into account, and considering all the advantages of satellite technology mentioned in the previous section, satellite-based solutions, should be considered fully as primary options for broadband network deployments, particularly for rural and remote areas. Several HTS and other advanced systems have recently been launched or are planned for the near future which are ushering in a new age of affordable, high-capacity, satellite connectivity. For example:

- The Inmarsat I-5 (Global Xpress) network is blanketing the world with high speed fixed and mobile broadband access over the Ka-band, with a total expected program cost of US$1.6 billion. The Inmarsat-6 satellites will feature single point peak capacity of ~ 1.5Gbps, and will include both Ka- and L-Band connectivity, enabling broadband capacity and highly reliable advanced mobile services. Inmarsat has announced a construction contract with Airbus to manufacture the first two Inmarsat-

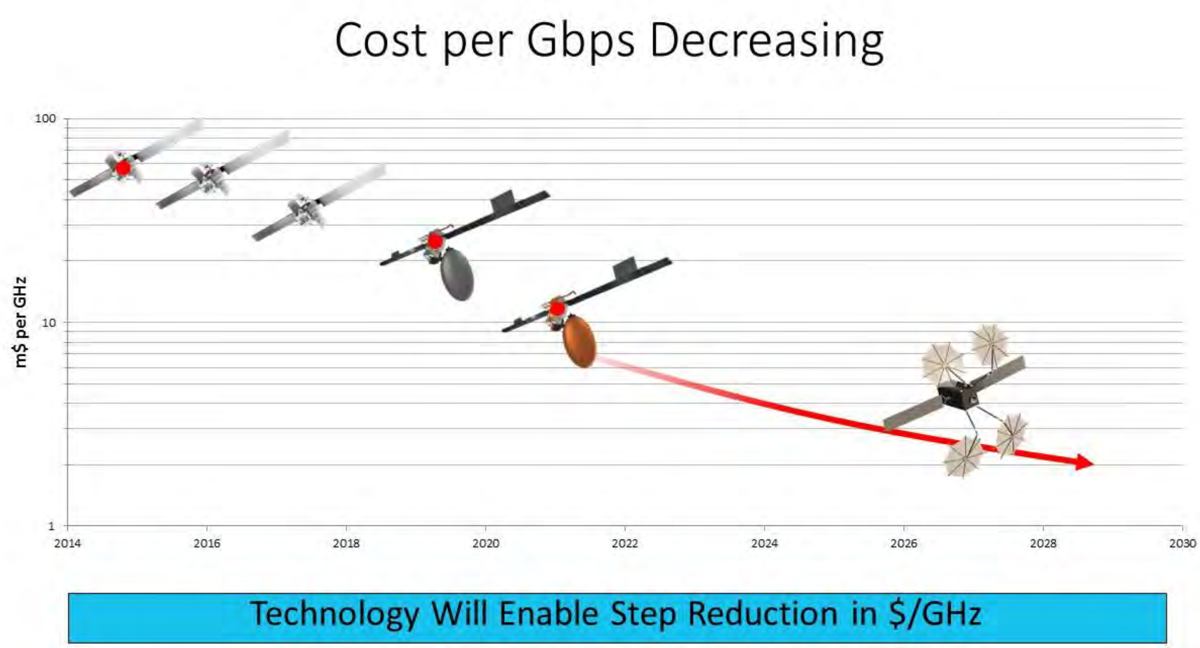
[45] SIA "Satellites and Export Credit Financing Fact Sheet" http://www.sia.org/wp-content/uploads/2010/12/SIA_Satellites_and_Export_Credit_Financing_Fact_Sheet_2014.pdf

6 satellites, valued in the region of US$600 million with the first satellite scheduled to deliver in 2020.

- Intelsat Epic^{NG} satellites will combine wide beams and spot beams with frequency reuses technology and provide high throughput capacity in both C-, Ku-, and Ka-band. The expected cost for seven Epic^{NG} satellites is between US$2.5 to 3 billion.
- Eutelsat has launched in 2016 two satellites – E 65 WA and E 117 WB - which will provide internet services and connectivity for Latin America. E 172 B is under construction to be launched in 2017 and provide connectivity on-board planes between eastern Asia and the western coasts of the Americas. In 2018, a new generation of HTS satellites – named Quantum - will provide internet services to mobile users and allocate the power of the satellite exactly on the basis of the users needs.
- ViaSat-2 is expected to be launched in 2017 with 350 Gbps capacity. ViaSat-3 is advertised as a three-satellite constellation with global coverage and 1 Tbps capacity per spacecraft. The first two ViaSat-3 satellites are expected to be delivered in 2019. ViaSat expects to spend US$1.4 Billion between 2017 and 2021 to fund its ViaSat-2 and ViaSat-3 programs.
- SES has procured several new satellites scheduled to come online in 2017, including its SES-12, SES-14, and SES-15 Ku-band high-throughput satellite systems, which together will carry 36 GHz of HTS capacity.
- O3b, currently has 12 satellites which offer 192 Gbps total throughput, up to 1.6 Gbps throughput per beam and low latency of <150 milliseconds. The system is designed to provide fiber-like IP trunking and cellular backhauling services to national fixed/mobile network, maritime, energy companies. The Cost for the initial constellation was $1.5B.
- OneWeb plans to build a low -Earth orbit (LEO) constellation of >700 satellites in Ku-band to provide global broadband connectivity. Each satellite is expected to cost under US$500,000 to construct. Total program costs are expected to exceed US$6 billion.

Taken together, the foregoing demonstrates massive recent and upcoming developments in the satellite industry in terms of capabilities, coverage, and cost. Satellite connectivity already performs comparably or better than terrestrial wired solutions in many developed and developing country environments. As the technology and market continue to evolve, satellite capabilities will continue to improve while the cost of satellite services will fall exponentially, bring satellite services in even greater parity with terrestrial solutions.

Figure 6: Impact of satellite technology development on cost per Gbps



Compared to the broadband deployment cost forecasts for deploying only cable and terrestrial wireless discussed previously, the costs of satellite systems make them attractive candidates for playing a key role in connecting the next 1.5 billion people around the world. Indeed, financing for many of these systems is already committed, and additional space segment capacity soon will be brought online. However, even though satellite broadband is a cost-effective way to provide connectivity, the investment required on the segment-in the form of earth stations and user terminals-and the cost of services, may still be prohibitive for some rural and remote communities. Through various funding and financing models, developing country governments can have a role in directing the investment in and introduction of new broadband services in developing markets, and can help ensure that the price of these new services remains within reach for their populations.

A March 2013 paper published by the ITU's Telecommunication Development sector identified four main funding options for access network deployment:[46]

1. Central Government Funding – treating the development of the access network as an essential facility to be funded centrally and then either leased to commercial providers or operated by a single commercial or governmental organization.
2. Localized Government Funding – similar to central government funding, but instead a local unit of government, such as a municipality, funds network deployment to address local needs.
3. Public-Private Funding – in which commercial operators can access government funds to defray a portion of deployment costs, for example to promote investment in rural areas.
4. Commercial (private) Funding – in which network operators fund network deployment themselves, from debt, cash on hand, or equity investors. Commercial business cannot afford to take on large loss making investments and so more profitable markets may be prioritized.

In addition, the Broadband Commission's Working Group on Finance and Investment also identified Sovereign Wealth Funds as an option for broadband network funding. These are investment funds owned by other governments and funded by foreign exchange and reserve assets. However, there are some potential negative effects to these funds, namely: political risks, lack of knowledge and experience, regulatory restrictions and investment conditions.

Governments may not be willing or able to take on the entire cost and operation of a satellite system, and commercial funding may not be available in markets unserved by current networks. Ultimately, a public-private partnership approach might be best-suited to ensuring that advanced commercial services are available in the neediest areas.

As with forecasting the costs of broadband deployment, there is substantial scholarship on examples and options for public-private partnerships. The ITU's "Smart Sustainable Development Model (SSDM) Report 2016" identified different public-private partnership

[46] ITU-D, *Strategies for the Deployment of NGN in a Broadband Environment* (March 2013) *at* http://www.itu.int/en/ITU-D/Regulatory-Market/Documents/NGN%20strategies-final-en.pdf.

scenarios through which a government authority and commercial companies can collaborate to facilitate deployment of a broadband network.[47]

1. Owner/Owner and financer – government becomes the owner of the solution, commissioning one or more companies for procurement, implementation, and operation of the project components. Vendors may be paid directly by the government (owner and financer model) or may donate the services in-kind. This is similar to the government funded financing models discussed above.
2. Joint Venture – government enters into a joint venture with one or more companies, jointly acting as the platform owner and service provider. The government might contribute substantial financial resources while the companies contribute goods and services in-kind. This model allows the government to take an active role in the project while sharing investments with commercial partners.
3. Facilitator – government becomes a facilitator of the new service by connecting commercial companies with development and aid organizations. The government can set the scope of the project and commission the private company, but the company remains responsible for funding and implementing the project, with assistance from charitable or development aid organizations engaged by the government.

ITU-D's "Trends in Telecommunication Reform 2016",[48] citing a 2012 Analysys Mason report,[49] structured its analysis somewhat differently and identified four common categories for broadband infrastructure public-private partnerships:

1. Private design, build and operate (DBO) – where a private operator retains ownership and control of the broadband network but benefits from receiving state funds, such as through investment in infrastructure in commercially unviable areas.
2. Public outsourcing – where a private operator is responsible for running a network under a government-funded contract.
3. Joint venture – a special-purpose vehicle or other legal entity is created by the commercial and government entities to invest in broadband infrastructure. Funding, ownership, and management responsibility shared between the private and public entity.

[47] "Smart Sustainable Development Model Report (2016)" at http://www.itu.int/dms_pub/itu-d/opb/str/D-STR-SSDM.01-2016-PDF-E.pdf

[48] "ITU-D's Trends in Telecommunication Reform 2016" at http://www.itu.int/pub/D-PREF-TTR.17-2016

[49] *See* Matt Yardley, Analysys Mason, *Developing successful Public-Private Partnerships to foster investment in universal broadband networks* (Sept. 2012) *available at* http://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR12/documents/GSR12_BBReport_Yardley_PPP_7.pdf.

4. Public DBO – the government has full funding responsibility and ownership of the assets, but elements of management/operations may be allocated to private contractors.

Different models may be appropriate depending on the circumstances of the deployment. Governments should explore the various public-private partnership models to determine whether one might fit their needs for network deployment.

In addition, the SSDM report also identified a number of multilateral and other financing organizations that might help support major development projects. These banks and organizations vet only high economic impact projects; however, they do offer research, consultation, and other resources such as non-refundable grants:

- World Bank Group
- International Finance Corporation
- Inter-American Development Bank
- Inter-American Investment Corporation
- Bill and Melinda Gates Foundation

In summary, satellite broadband is a cost effective way to provide connectivity in rural and remote regions. There are some financial resources that governments can turn to help fund the deployment of satellite broadband in national broadband strategies ranging from public-private partnerships to multi-lateral development banks. Therefore, connecting rural communities through satellite broadband is a financially sound and achievable decision for many countries.

CONCLUSION AND RECOMMENDATIONS

There is a still a large percentage of the world population without access to broadband infrastructure and 70% of people who do not have access to a broadband infrastructure are in rural areas. As we have demonstrated in this contribution, there is a strong negative correlation between access to broadband infrastructure and the percentage of population living in rural areas. Access to terrestrial technologies is limited or non-existent in many parts of the world, in particular in developing countries and sparsely populated rural areas and, therefore, satellite technology is uniquely placed for the delivery of broadband services in those areas either on its own, or in combination with other technologies.

New satellite systems are challenging conventional assumptions about speed, capacity, and latency and are therefore a solution to the problem of connecting the next 1.5 billion people around the world. Many satellite operators have recently deployed, or plan soon to deploy, systems such as the Inmarsat 1-5 and the Intelsat Epic that can really make a difference. Satellite broadband has proved its value to communities in Africa, Asia, the Americas and Australasia and this value has also been recognized by Internet giants such as Google and Facebook, which are developing plans to widen their use of satellite technology.

Technological advances have improved the quality, increased the capacity and reduced the costs of satellite services and enabled satellite operators to provide innovative solutions to bridging some aspects of the digital divide and providing broadband for all.

Estimates of the costs for providing broadband access for all have largely been based on the cost of terrestrial networks. In comparison, the cost for providing satellite broadband is considerably lower, due to its wide multipoint coverage from a single point. While the cost of a satellite is considerable, it is a “one-off” cost, recouped over the satellite’s lifetime. Nevertheless, commercial service providers need to be encouraged to make the necessary investment to provide services to markets which have not yet proved to be profitable.

One of the main challenges to providing broadband access to developing countries and rural and remote areas of the world is creating sufficient commercial incentives to bring satellite Internet services to these areas. In particular, although substantial space segment capacity will be available soon, the costs of services and user terminals, which have already been substantially reduced compared to previous times, may still be too expensive for some rural and remote locations. Solutions could be found through the development of public-private partnerships. National and local governments could be encouraged to consider establishing partnerships with private operators. These could be in the form of government financial assistance to an operator to facilitate services to less commercially viable areas. Alternatively, governments could consider outsourcing, joint ventures or allocation of some elements of management or operations to private contractors. In addition, in order to attract investments governments must ensure a solid, detailed, and transparent institutional and regulatory framework and a holistic vision to implement it.

Annex 1

Access to Broadband Infrastructure

Access to Broadband Infrastructure [50]

0-10% of the population has access to broadband infrastructure

Country	Number of People with Access to Broadband Infrastructure	Percentage of People with Internet Access
Eritrea	56,728	1.1 %
Timor-Leste	14,030	1.2 %
Burundi	167,512	1.5 %
Somalia	192,775	1.7 %
Guinea	236,932	1.8 %
Niger	439,164	2.1 %
Sierra Leone	160,188	2.4 %
Myanmar	1,353,649	2.5 %
Chad	387,063	2.7 %
Guinea-Bissau	66,284	3.5 %
DR Congo	3,101,210	3.9 %
Ethiopia	4,288,023	4.2 %
Madagascar	1,066,397	4.3 %
Central African Republic	224,432	4.5 %
Tanzania	2,895,662	5.3 %
Benin	628,683	5.6 %
Mozambique	1,834,337	6.4 %
Malawi	1,160,839	6.5 %
Afghanistan	2,279,167	6.8 %
Comoros	59,242	7.3 %
Togo	545,020	7.3 %
Congo	357,471	7.5 %
Liberia	395,063	8.6 %
Solomon Islands	58,423	9.8 %

[50] Source Internet Live Stats: http://www.internetlivestats.com/internet-users-by-country/

10%-25% of the population has access to broadband infrastructure

Country	Number of People with Access to Broadband Infrastructure	Percentage of People with Access to Broadband Infrastructure
Burkina Faso	1,894,498	10.2 %
Gabon	182,309	10.3 %
Cambodia	1,756,824	11.1 %
Djibouti	105,163	11.7 %
Papua New Guinea	906,695	11.7 %
Haiti	1,308,290	12.1 %
Mali	2,212,450	12.2 %
Rwanda	1,478,216	12.4 %
Kiribati	14,724	12.9 %
Iraq	4,892,463	13 %
Bangladesh	21,439,070	13.2 %
Turkmenistan	789,151	14.5 %
Namibia	392,181	15.6 %
Laos	1,087,567	15.7 %
Gambia	346,471	16.9 %
Mauritania	714,132	17.1 %
South Sudan	2,179,963	17.1 %
Nepal	4,962,323	17.2 %
Pakistan	34,342,400	17.8 %
Cameroon	4,311,178	18 %
Tajikistan	1.622.924	18.7%
Zambia	3,167,934	19 %
Uganda	7,645,197	19 %
Nicaragua	1,194,337	19.4 %
Algeria	7,937,913	19.7 %
Marshall Islands	10,709	20.2 %
Indonesia	53,236,719	20.4 %
Lesotho	444,376	20.6 %
Equatorial Guinea	181,657	20.9 %
Libya	1,335,705	21.1%
Zimbabwe	3,356,223	21 %
Botswana	492,787	21.4 %
Honduras	1,757,467	21.5 %
Côte d'Ivoire	5,122,897	22 %
Angola	5,951,453	23 %
Senegal	3,647,939	23.4 %
Yemen	6,773,228	24.7 %

http://www.broadbandcommission.org/Documents/publications/davos-discussion-paper-jan2016.pd25%-40% of the population has access to broadband infrastructure

Country	Number of People with Access to Broadband Infrastructure	Percentage of People with Access to Broadband Infrastructure
Sao Tome and Principe	49,686	25.6 %
Sudan	10,886,813	26.4 %
Guatemala	4,409,997	26.5 %
Swaziland	362,921	27.8 %
Ghana	7,958,675	28.4 %
Samoa	56,373	29 %
Sri Lanka	6,087,164	29.3 %
Syria	5,502,250	29.6 %
Vanuatu	82,764	30.6 %
Micronesia	32,749	31.2 %
Cuba	3,696,765	32.4 %
Egypt	30,835,256	33 %
Kyrgyzstan	2,076,220	34.4 %
India	462,124,989	34.8 %
Mongolia	1.069,693	35.6%
Bhutan	289,177	36.9 %
El Salvador	2,352,849	38.3 %
Grenada	41,675	38.8 %
Guyana	305,007	39.6 %

40%-60% of the population has access to broadband infrastructure

Country	Number of People with Access to Broadband Infrastructure	Percentage of People with Access to Broadband Infrastructure
Peru	13,036,965	41 %
Bolivia	4,478,400	41.1 %
Surinam	231,420	42.3 %
Cabo Verde	224,183	42.5 %
Mauritius	543,048	42.5 %
Thailand	29,078,158	42.7 %
Ecuador	7,055,575	43.1 %
Jamaica	1,216,098	43.4 %
Philippines	44,478,808	43.5 %
Ukraine	19,678,089	44.1 %
Belize	165,014	45 %
Kenya	21,248,977	45%
Mexico	58,016,997	45.1 %
Panama	1,803,261	45.2 %
Jordan	3,536,871	45.7 %
Nigeria	86,219,965	46.1 %
Fiji	419,958	46.8 %
Paraguay	3,149,519	46.8 %
Moldova	1,946,111	47.9 %
Tunisia	5,472,618	48.1 %
Iran	39,149,103	48.9 %
Armenia	1,510,906	49.9 %
Uzbekistan	15,453,227	51%
Dominican Republic	5,513,852	51.8 %
Viet Nam	49,063,762	52 %
South Africa	28,580,290	52 %
China	721,434,547	52.2 %
Georgia	2,104,906	52.9 %
Maldives	198,071	53.6 %
U.S Virgin Islands	57,485	54 %
Serbia	4,758,861	54 %
Kazakhstan	9,961,519	55.8 %
Colombia	27,664,747	56.9 %
Costa Rica	2,738,500	56.4%
Morocco	20,068,556	57.6 %
Seychelles	56,168	57.9 %
Venezuela	18,254,349	57.9 %
Romania	11,236,186	58 %
Turkey	46,196,720	58 %
Bulgaria	4,155,050	58.5 %
Saint Lucia	109,370	58.7 %

60%-80% of the population has access to broadband infrastructure

Country	Number of People with Access to Broadband Infrastructure	Percentage of People with Access to Broadband Infrastructure
St. Vincent & Grenadines	65,984	60.2 %
Belarus	5,786,572	61 %
Azerbaijan	6,027,647	61.1 %
Bosnia and Herzegovina	2,343,255	61.6 %
Montenegro	388,057	62 %
State of Palestine	3,007,869	62.7 %
Albania	1,823,233	62.8 %
French Polynesia	182,442	63.9 %
Saudi Arabia	20,813,695	64.7 %
Greece	7,072,534	64.8%
Antigua and Barbuda	60,306	65 %
Uruguay	2,238,991	65 %
Italy	39,211,518	65.6 %
Dominica	48,249	66.1 %
St. Kitts and Nevis	37,210	66.2 %
Brazil	139,111,185	66.4 %
Portugal	6,930,762	67.3 %
Greenland	37,899	67.4 %
Malaysia	21,090,777	68.6 %
Trinidad and Tobago	942,713	69.1 %
TFYR Macedonia	1,439,089	69.2 %
Argentina	30,359,855	69.2 %
New Caledonia	186,502	70 %
Oman	3,310,260	71.1 %
Russia	102,258,256	71.3 %
Cyprus	844,680	71.8 %
Slovenia	1,490,358	72 %
Brunei	310,205	72.3 %
Poland	27,922,152	72.4 %
Israel	5,941,174	72.5 %
Cayman Islands	45,038	74.1 %
Hong Kong	5,442,101	74.1 %
Croatia	3,133,485	74.2 %
Lebanon	4,545,007	75.9 %
Latvia	1,491,951	76.3 %
Lithuania	2,199,938	77.2 %
Chile	14,108,392	77.8 %
Malta	334,056	79.6 %
Kuwait	3,202,110	79.9 %

80%-100% of the population has access to broadband infrastructure

Country	Number of People with Access to Broadband Infrastructure	Percentage of People with Access to Broadband Infrastructure
Hungary	7,874,733	80.2 %
Barbados	228,717	80.3 %
Ireland	3,817,392	81 %
Austria	6,953,400	81.1 %
Spain	37,865,104	82.2%
Singapore	4,699,204	82.5 %
Slovakia	4,477,641	82.5 %
Puerto Rico	3,047,311	82.8 %
Bahamas	333,143	84.8 %
Australia	20,679,490	85.1 %
South Korea	43,274,132	85.7 %
France	55,860,330	86.4 %
Switzerland	7,302,714	87.2 %
Aruba	91,532	87.8 %
Germany	71,016,605	88 %
Czech Republic	9,323,428	88.4 %
Belgium	10,060,745	88.5 %
Canada	32,120,519	88.5 %
U.S.	286,942,362	88.5 %
New Zealand	4,078,992	89.4%
Japan	115,11,595	91.1%
Estonia	1,196,521	91.4 %
Bahrain	1,278,752	91.5 %
United Arab Emirates	8,515,420	91.9 %
Qatar	2,108,970	92 %
Finland	5,107,402	92.5 %
U.K.	60,273,385	92.6 %
Monaco	35,196	93%
Sweden	9,169,705	93.1 %
Netherlands	15,915,076	93.7 %
Luxembourg	548,807	95.2 %
Liechtenstein	36,183	95.8 %
Denmark	5,479,054	96.3 %
Andorra	66,728	96.5 %
Bermuda	60,047	97.4 %
Norway	5,167,573	98 %
Faeroe Islands	47,515	98.5 %
Iceland	331,778	100 %

Annex 2

Percentage of Population Living in Rural Areas

Percentage of Population Living in Rural Areas[51]

100%-80%

Country	Percentage of Population in Rural Areas
Trinidad and Tobago	91%
Burundi	88%
Papua New Guinea	87%
Liechtenstein	86%
Malawi	84%
Uganda	84%
Nepal	82%
Niger	82%
Saint Lucia	82%
Sri Lanka	82%
Ethiopia	81%
Samoa	81%
South Sudan	81%

[51] Source: World Bank http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS

80%-60%

Country	Percentage of Population in Rural Areas
Cambodia	79%
Swaziland	79%
Chad	78%
Eritrea	78%
Micronesia	78%
Solomon Islands	78%
Antigua and Barbuda	76%
Kenya	75%
Afghanistan	74%
Vanuatu	74%
Lesotho	73%
Tajikistan	73%
Comoros	72%
Guyana	72%
Rwanda	72%
Burkina Faso	71%
Tanzania	69%
Barbados	68%
Mozambique	68%
St. Kitts and Nevis	68%
Timor-Leste	68%
Viet Nam	67%
Zimbabwe	67%
Bangladesh	66%
India	66%
Madagascar	66%
Myanmar	66%
Sudan	66%
Yemen	66%
Grenada	64%
Kyrgyzstan	64%
Uzbekistan	64%
Guinea	63%
Bhutan	62%
Laos	62%
Pakistan	62%
Mali	61%
Somalia	61%
Togo	61%

60%-40%

Country	Percentage of Population in Rural Areas
Bosnia and Herzegovina	60%
Central African Republic	60%
Equatorial Guinea	60%
Mauritius	60%
Sierra Leone	60%
Zambia	60%
Aruba	58%
DR Congo	58%
Faroe Islands	58%
Angola	57%
Egypt	57%
Senegal	57%
Belize	56%
Benin	56%
Kiribati	56%
Maldives	56%
Philippines	56%
Moldova	55%
Namibia	54%
Nigeria	53%
Guinea-Bissau	51%
Liberia	51%
Thailand	51%
Slovenia	50%
St. Vincent & Grenadines	50%
Turkmenistan	50%
Guatemala	49%
Côte d'Ivoire	47%
Fiji	47%
Georgia	47%
Ghana	47%
Indonesia	47%
Kazakhstan	47%
Azerbaijan	46%
Cameroon	46%
China	46%
Honduras	46%
Romania	46%
Seychelles	46%
Slovakia	46%
Jamaica	45%
Serbia	45%
Albania	44%
French Polynesia	44%
Botswana	43%
Haiti	43%
Syria	43%
TFYR Macedonia	43%
Nicaragua	42%
Croatia	41%
Gambia	41%
Mauritania	41%
Paraguay	41%

40%-20%

Country	Percentage of Population in Rural Areas
Morocco	40%
Poland	39%
Armenia	37%
Ireland	37%
Portugal	37%
Ecuador	36%
Montenegro	36%
South Africa	36%
Cabo Verde	35%
Congo	35%
Sao Tome and Principe	35%
Austria	34%
El Salvador	34%
Panama	34%
Surinam	34%
Cyprus	33%
Latvia	33%
Lithuania	33%
Tunisia	33%
Bolivia	32%
Estonia	32%
Dominica	31%
Iraq	31%
Italy	31%
Ukraine	31%
Algeria	30%
New Caledonia	30%
Hungary	29%
Mongolia	29%
Marshall Islands	28%
Czech Republic	27%
Iran	27%
Turkey	27%
Bulgaria	26%
Malaysia	26%
Russia	26%
Switzerland	26%
Germany	25%
Belarus	24%
Colombia	24%
Costa Rica	24%
Brunei	23%
Cuba	23%
Djibouti	23%
Oman	23%
Dominican Republic	22%
Greece	22%
Libya	22%
Peru	22%
France	21%
Mexico	21%
Spain	21%

20%-0%

Country	Percentage of Population in Rural Areas
Norway	20%
U.S.	19%
Canada	18%
South Korea	18%
U.K.	18%
Bahamas	17%
Jordan	17%
Saudi Arabia	17%
Finland	16%
Brazil	15%
United Arab Emirates	15%
Andorra	14%
Greenland	14%
New Zealand	14%
Sweden	14%
Gabon	13%
Denmark	12%
Lebanon	12%
Australia	11%
Bahrain	11%
Chile	11%
Venezuela	11%
Luxembourg	10%
Netherlands	10%
Argentina	8%
Israel	8%
Japan	7%
Iceland	6%
Puerto Rico	6%
Malta	5%
U.S Virgin Islands	5%
Uruguay	5%
Belgium	2%
Kuwait	2%
Qatar	1%
Bermuda	0%
Cayman Islands	0%
Hong Kong	0%
Monaco	0%
Singapore	0%

Annex 3

Underserved Populations in Rural Areas

Underserved Populations in Rural Areas[52]

*The countries represented below are countries where less 60% of the population has access to broadband infrastructure and more than 40% live in rural regions.

0-10% of the population has access to broadband infrastructure

Country	Number of People with Access to Broadband Infrastructure	Percentage of People with Internet Access	Percentage of People with Access to Broadband Infrastructure
Eritrea	56,728	1.1 %	78%
Timor-Leste	14,030	1.2 %	68%
Burundi	167,512	1.5 %	88%
Somalia	192,775	1.7 %	61%
Guinea	236,932	1.8 %	63%
Niger	439,164	2.1 %	82%
Sierra Leone	160,188	2.4 %	60%
Myanmar	1,353,649	2.5 %	66%
Chad	387,063	2.7 %	78%
Guinea-Bissau	66,284	3.5 %	51%
DR Congo	3,101,210	3.9 %	58%
Ethiopia	4,288,023	4.2 %	81%
Madagascar	1,066,397	4.3 %	66%
Central African Republic	224,432	4.5 %	60%
Tanzania	2,895,662	5.3 %	69%
Benin	628,683	5.6 %	56%
Mozambique	1,834,337	6.4 %	68%
Malawi	1,160,839	6.5 %	84%
Afghanistan	2,279,167	6.8 %	74%
Comoros	59,242	7.3 %	72%
Togo	545,020	7.3 %	61%
Liberia	395,063	8.6 %	51%
Solomon Islands	58,423	9.8 %	78%

[52] Sources Internet Live Stats http://www.internetlivestats.com/internet-users-by-country/ and World Bank http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS

10%-25% of the population has access to broadband infrastructure

Country	Number of People with Access to Broadband Infrastructure	Percentage of People with Access to Broadband Infrastructure	Percentage of population that lives in Rural areas
Burkina Faso	1,894,498	10.2 %	71%
Cambodia	1,756,824	11.1 %	79%
Papua New Guinea	906,695	11.7 %	87%
Haiti	1,308,290	12.1 %	43%
Mali	2,212,450	12.2 %	61%
Rwanda	1,478,216	12.4 %	72%
Kiribati	14,724	12.9 %	56%
Bangladesh	21,439,070	13.2 %	66%
Turkmenistan	789,151	14.5 %	50%
Namibia	392,181	15.6 %	54%
Laos	1,087,567	15.7 %	62%
Gambia	346,471	16.9 %	41%
Mauritania	714,132	17.1 %	41%
South Sudan	2,179,963	17.1 %	81%
Nepal	4,962,323	17.2 %	82%
Pakistan	34,342,400	17.8 %	62%
Cameroon	4,311,178	18 %	46%
Tajikistan	1.622.924	18.7%	73%
Zambia	3,167,934	19 %	60%
Uganda	7,645,197	19 %	84%
Nicaragua	1,194,337	19.4 %	42%
Indonesia	53,236,719	20.4 %	47%
Lesotho	444,376	20.6 %	73%
Equatorial Guinea	181,657	20.9 %	60%
Zimbabwe	3,356,223	21 %	67%
Botswana	492,787	21.4 %	43%
Honduras	1,757,467	21.5 %	46%
Côte d'Ivoire	5,122,897	22 %	47%
Angola	5,951,453	23 %	57%
Senegal	3,647,939	23.4 %	57%
Yemen	6,773,228	24.7 %	66%

25%-40% of the population has access to broadband infrastructure

Country	Number of People with Access to Broadband Infrastructure	Percentage of People with Access to Broadband Infrastructure	Percentage of population that lives in Rural areas
Sudan	10,886,813	26.4 %	66%
Guatemala	4,409,997	26.5 %	49%
Swaziland	362,921	27.8 %	79%
Ghana	7,958,675	28.4 %	47%
Samoa	56,373	29 %	81%
Sri Lanka	6,087,164	29.3 %	82%
Syria	5,502,250	29.6 %	43%
Vanuatu	82,764	30.6 %	74%
Micronesia	32,749	31.2 %	78%
Egypt	30,835,256	33 %	57%
Kyrgyzstan	2,076,220	34.4 %	64%
India	462,124,989	34.8 %	66%
Bhutan	289,177	36.9 %	62%
Grenada	41,675	38.8 %	64%
Guyana	305,007	39.6 %	72%

40%-60% of the population has access to broadband infrastructure

Country	Number of People with Access to Broadband Infrastructure	Percentage of People with Access to Broadband Infrastructure	Percentage of population that lives in Rural areas (2014)
Mauritius	543,048	42.5 %	60%
Thailand	29,078,158	42.7 %	51%
Jamaica	1,216,098	43.4 %	45%
Philippines	44,478,808	43.5 %	56%
Belize	165,014	45 %	56%
Kenya	21,248,977	45%	75%
Nigeria	86,219,965	46.1 %	53%
Fiji	419,958	46.8 %	47%
Paraguay	3,149,519	46.8 %	41%
Moldova	1,946,111	47.9 %	55%
Uzbekistan	15,453,227	51%	64%
Viet Nam	49,063,762	52 %	67%
China	721,434,547	52.2 %	46%
Georgia	2,104,906	52.9 %	47%
Maldives	198,071	53.6 %	56%
Serbia	4,758,861	54 %	45%
Kazakhstan	9,961,519	55.8 %	47%
Morocco	20,068,556	57.6 %	40%
Seychelles	56,168	57.9 %	46%
Romania	11,236,186	58 %	46%
Saint Lucia	109,370	58.7 %	82%

Annex 4

Key Findings of Investment Needs

Table from "Working Together to Connect the World by 2020"- Discussion Paper by the International Telecommunications Union[53]

Country / Region	Technology and coverage target	Investment Required	Author / Type of Study
Europe, 2013	100% NGA by 2020 (>= 30 Mbps)	€ 82 billion (€52 billion rural (14%), €22 billion semi-rural and €8 billion urban) € 2,000 per HH rural, € 150 per HH urban	Point Topic
Europe	NGA, Digital Agenda	€ 180-€ 270 billion	European Commission
Europe, 2012	FTTH, Digital Agenda Target 2	€ 202 billion	FTTH Council
Europe	Digital Agenda Target 2, excluding WiMAX and Satellite	€ 73-221 billion (or € 517-707 per HH)	Koutroumpis for EIB
MENA, 2014	FTTC and LTE at 10 Mbps 100%, 30 Mbps 50% - backbone, backhaul and international connectivity	US$ 28-35 billion	World Bank
Latin America and Caribbean	NGN	US$ 355 billion	AHCIET
Africa, 2007		US$ 57 billion	GSMA
24 African countries 2008-2015	Universal Voice and broadband services	US$ 5.8 billion for voice coverage US$ 6 billion for broadband coverage US$ 1.8 billion for inter-continental connectivity (Sub-Saharan countries) US$ 229-515 million for intraregional connectivity (Sub-Saharan countries)	World Bank "Costing the Needs for Investment in ICT Infrastructure in Africa"
UK, 2010	Wireless and Satellite	Scenario A GBP500 / home Scenario B GBP2800 / home Scenario C GBP5800 / home	Analysys Mason
Europe, 2012	Satellite	€250-€350 million per sat-ellite (1 satellite connecting 1 million subscribers)	European Commission, Eutelsat, SES Broadband Services, Skylogic

53 ITU, *Working Together to Connect the World by 2020* (2016) *at* http://www.broadbandcommission.org/Documents/publications/davos-discussion-paper-jan2016.pdf

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