

# The Provision of Satellite Broadband Services in Latin America and the Caribbean

Authors:

Wolfgang Wagner

Renata Brazil David

Antonio Garcia Zaballos





# The Provision of Satellite Broadband Services in Latin America and the Caribbean

Authors:

Wolfgang Wagner

Renata Brazil David

Antonio Garcia Zaballos



**Cataloging-in-Publication data provided by the  
Inter-American Development Bank  
Felipe Herrera Library**

Wagner, Wolfgang.

The provision of satellite broadband services in Latin America and the Caribbean / Wolfgang Wagner, Renata Brazil David, and Antonio García Zaballos.

p. cm. — (IDB Monograph ; 468)

Includes bibliographic references.

1. Broadband communication systems-Latin America. 2. Broadband communication systems-Caribbean Area. 3. Artificial satellites in telecommunication-Latin America. 4. Artificial satellites in telecommunication-Caribbean Area. 5. Rural telecommunication-Latin America. 6. Rural telecommunication-Caribbean Area. I. Brazil David, Renata. II. García Zaballos, Antonio. III. Inter-American Development Bank. Capital Markets and Financial Institutions Division. IV. Title. V. Series.

IDB-MG-468

**Publication Code:** IDB-MG-468

**JEL Codes:** A33, L86, L88, L96, O38

**Keywords:** Argentina, broadband, e-services, ICTs, infrastructure, Latin America and the Caribbean, Nicaragua, regulation, rural, Peru, policy, satellite, technology, telecommunications, Trinidad and Tobago

Copyright © 2016 Inter-American Development Bank. This work is licensed under a Creative Commons IGO 3.0 Attribution-NonCommercial-NoDerivatives (CC-IGO BY-NC-ND 3.0 IGO) license (<https://creativecommons.org/licenses/by-nc-nd/3.0/igo/legalcode>) and may be reproduced with attribution to the IDB and for any non-commercial purpose. No derivative work is allowed.

Any dispute related to the use of the works of the IDB that cannot be settled amicably shall be submitted to arbitration pursuant to the UNCITRAL rules. The use of the IDB's name for any purpose other than for attribution, and the use of the IDB's logo shall be subject to a separate written license agreement between the IDB and the user and is not authorized as part of this CC-IGO license.

Note that the link provided above includes additional terms and conditions of the license.

The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the Inter-American Development Bank, its Board of Directors, or the countries they represent.



Inter-American Development Bank  
1300 New York Avenue, N.W.  
Washington, D.C. 20577  
[www.iadb.org](http://www.iadb.org)

**The Institutions for Development Sector was responsible for the production of this publication.**

**External Vendors:**

Production Editor: *Sarah Schineller (A&S Information Specialists, LLC)*

Editor: *Leslie Hunter*

Design: *Word Express, Inc.*

Proofreader: *Sarah Hunter*

# Table of Contents

---

Acknowledgments .....	v
About the Contributing Organizations and Individual Contributors.....	vii
Introduction .....	xi
<b>Chapter 1: The Principles of Satellite Broadband Telecommunications.....</b>	<b>1</b>
Satellite Telecommunications Basics .....	3
Managing the Resources .....	4
Orbits for Broadband Satellite Systems .....	5
A Brief Excursion into Technology.....	7
<b>Chapter 2: The Choice between Broadband Technologies and the Satellite Solution .....</b>	<b>9</b>
Strengths and Limitations of Fiber Optic Cables.....	9
Satellite Broadband Specifics.....	11
The Role of Terrestrial Microwave Systems.....	12
The Satellite Solution: Network Architecture for Satellite Broadband Service .....	13
Combining Alternative Media.....	15
Satellite Broadband in Light of the Value Chain and Business Models.....	17
<b>Chapter 3: The Provision of Satellite Telecommunications Services .....</b>	<b>19</b>
History and State of the Industry .....	19
How to Procure Satellite Transmission Capacity: Lease vs. Purchase.....	20
Regional Consortia .....	22
Cost, Pricing, and Related Information .....	23
Reducing Initial Costs and Risks .....	23
Summary and Key Findings .....	24
<b>Chapter 4: The Implementation of Satellite Broadband Services .....</b>	<b>25</b>
Policy, Regulation, and Broadband Service Stakeholders .....	26
Making Rural Broadband Economically Viable.....	29
Technology Alternatives for the End-User .....	32
Broadband via Wireless Backhaul over Satellite.....	32
The Role of the Internet Service Provider.....	32
Consumer Premises Issues.....	37

Ancillary Success Factors .....	42
Consumer Broadband Equipment Providers.....	48
Summary and Key Findings .....	49
<b>Chapter 5: Satellite Broadband Solutions and Selected Examples.....</b>	<b>51</b>
General Broadband Service Structure in Latin America and the Caribbean .....	52
Satellite Broadband Ecosystem in Latin America and the Caribbean .....	53
Selected Country-specific Examples of Satellite Based Solutions .....	53
Regional and Global Examples of Satellite-based Solutions .....	57
Looking Ahead: High Throughput Satellites for the LAC Region .....	62
Summary and Key Findings .....	64
<b>Chapter 6: The Focus Countries.....</b>	<b>65</b>
The Focus Countries from a Global Perspective.....	65
Argentina.....	70
Summary and Key Recommendations for Argentina.....	78
Republic of Nicaragua.....	80
Summary and Key Recommendations for Nicaragua.....	85
Republic of Peru .....	85
Summary and Key Recommendations for Peru .....	94
Republic of Trinidad and Tobago .....	95
Summary and Key Recommendations for Trinidad and Tobago.....	101
<b>Chapter 7: Satellite Solutions for the LAC Region:</b>	
<b>Final Thoughts and Proposed Steps for Implementation .....</b>	<b>103</b>
References.....	107
<b>Annexes</b>	
Annex I: Satellite Operators in the LAC Region.....	113
Annex II: Renewable Energy Solutions for Broadband.....	122
Annex III: Consumer Broadband Equipment Providers active in LAC Region.....	124

# Acknowledgments

---

The International Telecommunications Satellite Organization (ITSO) compiled a team of experts to carry out this study, entitled *The Provision of Satellite Broadband Services in Latin America and the Caribbean*, for the Inter-American Development Bank (IDB). The team included Wolfgang Wagner, the lead consultant on this project, Arnold Meyers, Carlos Placido, and Friedrich H. Luz. These experts were chosen from different backgrounds related to telecommunications and information and communication technology so that the publication would be comprehensive.

Renata Brazil David, ITSO's Director of Legal Affairs, and Antonio Garcia Zaballos, IDB's Lead Specialist on telecommunications, acted as team leaders for this project. Jose Toscano, ITSO's Director General, reviewed the publication and provided guidance and insights.

The authors wish to acknowledge the valuable contributions and comments provided by the following individuals: Lorena Cano Cuadra, Technical Advisor for the Broadband Program at the IDB; Enrique Iglesias Rodriguez, Telecommunications Specialist at the IDB; and Clara Langevin, ITSO's research assistant.





# About the Contributing Organizations and Individual Contributors

---

## **The International Telecommunications Satellite Organization**

The International Telecommunications Satellite Organization (ITSO), formerly abbreviated and referred to as INTELSAT, is the continuation of the intergovernmental organization established by treaty in 1973. Since ITSO's restructuring in 2001, the organization has been tasked with the mission to ensure that Intelsat, S.A. provides public telecommunications services, including voice, data, and video, on a global and non-discriminatory basis. Since its establishment, ITSO has proved to be an efficient catalyst for global cooperation in satellite communications. It has promoted cross-border flows of information that are vital to business, trade, and peace, and it has been instrumental in linking the developing countries to the global economy and enhancing the competitiveness of their economies. Headquartered in Washington DC, ITSO currently has 149 member countries.

## **The Inter-American Development Bank**

The Inter-American Development Bank (IDB) supports efforts by Latin American and Caribbean countries to reduce poverty and inequality. It aims

to bring about development in a sustainable and environmentally friendly way. The IDB is the largest source of development financing for the Latin American and Caribbean region, with a strong commitment to achieve measurable results, increased integrity, transparency, and accountability. It has an evolving reform agenda that seeks to increase its development impact in the region. The IDB provides loans, grants, and technical assistance, as well as develops research. Its members include 48 shareholding countries, 26 of which are from the Latin American and Caribbean region.

## **Wolfgang Wagner**

Wolfgang Wagner served as the lead consultant in this project. He has been part of the global satellite community and possesses extensive knowledge on ITSO and its role. Mr. Wagner served as Senior Director of Services and Marketing at Intelsat from 1989 to 1994, and was subsequently appointed as Intelsat Governor for Germany, Croatia, and Bulgaria. He was Chairman of the Board of Governors during the first privatization phase of the organization and following its privatization served as Deputy Chairman of the Board of Directors. Additionally, he has worked for Deutsche

Telekom AG, he was a policy and product-placement consultant to German space industry, and he co-founded Spacelink International, LLC, a U.S.-based specialized telecommunications service provider, now known as DRS Technologies. In Europe, Mr. Wagner was co-founder and Chairman of Global Radio S.A., Luxemburg, and a co-owner of Audio GmbH and Pontis Messtechnik GmbH, both specialized electronics development companies in Germany. Mr. Wagner received a Master of Sciences in Telecommunications Engineering from the Technical University of Darmstadt, Germany, and a post-graduate degree in Telecommunications Business and Administration from the German federal government.

### **Renata Brazil David**

Renata Brazil David was a team leader for this project. She is ITSO's Director of Legal Affairs, responsible for managing the legal issues pertaining to the organization, supporting the organization's relations with its stakeholders, and promoting its initiatives. She is actively involved in the ITU's Smart Sustainable Development Model Initiative, at the Broadband Commission for Sustainable Development and is the Head of the ITSO Program on International Communications Regulation and Policy at American University Washington College of Law. Dr. Brazil David has several years of experience in legal research. She is an adjunct professor at American University, where she teaches ICT Regulation and Policy, Business Law, and Arbitration, and she is a Member of the Advisory Board of the Brazil-U.S. Legal and Judicial Studies Program. She holds a Masters of Law from the University of Essex and a Ph.D. in Law from American University Washington College of Law.

### **Antonio Garcia Zaballos**

Antonio Garcia Zaballos was a team leader for this project. He is the Lead Specialist on Telecommunications in the Institutions for Development

Sector at the IDB and the leader of the Broadband Initiative. He has more than 15 years of experience in the telecom sector, where he has been working in different positions in different companies. At Deloitte Spain, Dr. Garcia Zaballos led the practice of regulation and strategy, and previously served as the Head of the Cabinet for Economic Studies of Regulation in Telefónica of Spain. He was Deputy Director of Economic Analysis and Markets at the Spanish Telecom Regulator (CMT). He holds a Ph.D. in Economics from the University Carlos III of Madrid and is an associate professor of Applied Finance to Telecommunications at the Instituto de Empresa Business School. He is the author of several publications on economic and regulatory aspects in the telecommunications sector.

### **Friedrich H. Luz**

Friedrich H. Luz is an independent telecommunications consultant and certified project management professional in Washington, DC, with 30 years of business, technical, and operational experience in the satellite services industry. During his 27-year career with Intelsat, he held various positions, including program director, technical manager, line and operations manager, and project engineer. He was responsible for a wide variety of programs and projects, including planning, requirements definition, integration and testing, delivery, and operation of satellite-based broadband and enterprise services, hybrid satellite/terrestrial data network infrastructure, network management and monitoring systems, satellite service re-arrangements, and teleport build-out and consolidation efforts. He holds a Master of Science degree in Telecommunications and Computers from George Washington University and a degree (diploma) in Physics from the University of Tuebingen, Germany.

### **Arnold Meyers**

Mr. Meyers provided knowledge in the operations of satellite-based telecommunication systems in

Latin America. Arnold Meyers formed Link International Group LLC in 1995, a company providing a range of consulting services to the satellite and space technology industry, including high-level outsourcing, business development, and mergers and acquisitions. Prior to forming Link, Mr. Meyers was head of Intelsat's Media and Entertainment business with responsibility for marketing, sales, and business development. He also held senior level positions in the areas of technical and service operations, emergency restoration, 24-hour service centers including representation on several advisory boards, and steering committees. Mr. Meyers holds a degree in Business from the University of Maryland. He has studied at the master's level in satellite telecommunications at George Washington University.

## **Carlos Placido**

Carlos Placido, a consultant and senior analyst, provided extensive knowledge of satellite Internet and broadband technology, namely, planning and operational aspects in Latin America. He has been involved in numerous strategic consulting projects as well as research and management activities, including global market research studies for NSR, technology assessment and business development support for technology vendors, and project management at Telefónica. Until 2004, Mr. Placido led a research and development team of principal and senior engineers at the Intelsat Technical Laboratories in Washington, DC. He is a contributor and administrator for Satcom Post, an online professional knowledge-sharing platform. Mr. Placido holds an engineering degree from the University of Buenos Aires and an MBA from the University of Maryland, Smith School of Business.



# Introduction

---

The transformative power of broadband as an enabler of economic growth has been widely recognized, and access to broadband connectivity has become a key priority of the twenty-first century. The implementation of a telecommunications infrastructure, in urban and rural areas alike, has become a major political and regulatory objective in many countries.

Nevertheless, the digital divide, that is, the gap in access to information and communication technologies (ICTs) and use of the Internet depending on socioeconomic status and geographic region, hinders economic growth in many countries. Globally, 3.2 billion people, or only 43.4 percent of the world's population, have access to the Internet (BCDD, 2015). This gap is even more accentuated in rural and remote areas, where mainstream broadband infrastructure, such as fiber optic cables, is limited.

In Latin America and the Caribbean (LAC), it is crucial for socioeconomic development that countries have strong telecommunications infrastructure to benefit from broadband applications. A 2012 IDB study estimates that a 10 percent increase in broadband availability would result in an average increase of 3.2 percent in GDP, 2.6 percent in productivity, and the creation of more than 67,000 new jobs (Garcia Zaballos and Lopéz-Rivas, 2012). However, the digital divide remains a challenge in the LAC region.

Considering that the LAC region has vast areas of low population density, located far from urban

centers, and that the rural population represents a substantial segment of the overall population, the best technical and economic solutions to deliver broadband services in those areas must be determined. Terrestrial technologies for the provision of broadband require substantial investments in infrastructure and are therefore financially burdensome if not cost-prohibitive in regions of low population density, such as the rural areas of the LAC region. To bridge the digital divide, it will be necessary to plan, finance, implement, and operate an efficient combination of fiber optic cable systems, cellular/microwave wireless technology, and satellite telecommunications.

This publication focuses on particular network architectures in which satellite broadband is the best alternative for the provision of broadband connectivity. It emphasizes that, since operational satellite systems already serve all habitable places on the planet, satellite broadband is an undeniable asset for the LAC region. It illustrates how satellite technology can complement terrestrial networks by providing broadband access almost instantaneously in any geographic location, including underserved areas throughout the world.

The objective of this study is to provide decision makers with the necessary working knowledge and information to help them create enabling policies and regulatory environments for the implementation of satellite broadband. It provides policymakers with a comprehensive toolkit. It includes the following aspects:

- A brief introduction to satellite technology in space and on the ground
- Scenarios in which the satellite solution is the best option for service compared to other broadband technologies
- The main satellite operators and service providers in the LAC region
- Procurement of satellite transmission capacity and the benefits and ramifications of purchasing vs. leasing
- Important policy and regulatory trends and relevant broadband service stakeholders
- End-user considerations, such as service-level agreements (SLAs), managing service quality and throughput, and training
- Successful implementation of satellite-based solutions for sustainable development in Australia, Brazil, Colombia, Mexico, Southeast Asia, and the United States

The study analyzes the digital divide in four countries in the LAC region: Argentina, Nicaragua, Peru, and Trinidad and Tobago. The analysis looks at the following characteristics in each country: demographic and socioeconomic aspects; current broadband trends, a description of the telecommunications environment, the main telecom players, and industry dynamics; a description of the regulatory authority and framework; the public-private interplay; and the national broadband plan. It also contains country-specific recommendations for bridging the digital divide and improving access to broadband.

To facilitate understanding of the deployment and use of satellite broadband, the study is divided into seven chapters. They cover policy, regulation, technology, planning, financing, implementation, and operation in the LAC region. The following is a synopsis of the topics covered in each chapter:

#### **CHAPTER 1: Principles of Satellite Telecommunications**

This chapter addresses the basic principles of satellite telecommunications, such as satellite transmission relays, satellite orbital allocation and management, high throughput satellites (HTS), and the basic subsystem of a satellite.

#### **CHAPTER 2: The Choice between Broadband Technologies and the Satellite Solution**

This chapter introduces the various broadband technology alternatives, their strengths and limitations, together with network architecture models for different geographic and socioeconomic deployment scenarios.

#### **CHAPTER 3: The Provision of Satellite Telecommunications Services**

This chapter provides an overview of the satellite telecommunications service industry, including the main operators in the LAC region.

#### **CHAPTER 4: Implementation of Satellite Broadband Services**

This chapter identifies, from the end-user perspective, critical factors for the initial deployment and the sustainable operation of satellite-based Internet broadband services in rural areas. It also explores the service characteristics that satellite Internet service providers (ISPs) offer to individual end-users.

#### **CHAPTER 5: Satellite Broadband Solutions and Selected Examples**

To compile best practices for recommendations, this study analyzed examples of current satellite broadband systems at the national, regional, and global levels, in the LAC region and comparable regions. Chapter 5 summarizes the relevant findings.

#### **CHAPTER 6: The Focus Countries**

A main component of this study was a gap analysis of four focus countries (Argentina, Nicaragua, Peru, and Trinidad and Tobago). Chapter 6 includes policy and infrastructure recommendations for each country.

#### **CHAPTER 7: The Satellite Solution for the LAC Region: Final Thoughts and Proposed Steps for Implementation**

This closing chapter will look at some of the main conclusions from the study as well as providing a checklist and next steps for policymakers looking to provide broadband services via satellite.

# The Principles of Satellite Broadband Telecommunications

It is increasingly evident that widespread access to information and communication technologies (ICTs), especially broadband, is necessary for sustainable development. ICTs are a catalyst for enhancing economic growth, expanding productivity and competition, and aggregating knowledge. ICTs, especially broadband, allow and increase participation in the global economy (World Bank, InfoDev, and the International Telecommunications Union, 2011). Through access to broadband, developing countries and isolated communities are better able to gain access to education, healthcare, and commercial services.

The delivery of broadband communications in urban centers and rural areas has become a major political and regulatory objective in many countries. The United Nations (UN) has recognized the availability of broadband infrastructure worldwide as an essential prerequisite to the economic development of countries (UN News Centre, 2011). Policymakers, regulators, and industry acknowledge the critical importance of broadband.

In recent years, the criteria for defining the term broadband have evolved significantly. A decade ago, the Internet provided these services quite adequately with data speeds substantially below 1 Megabit per second (Mbps).<sup>1</sup> This led the International Telecommunications Union (ITU) and the Organisation for Economic Co-operation and Development (OECD) to declare that the minimum

broadband transmission speed should be 256 kilobits per second (kbps) for uploads and downloads (ITU, 2012; OECD, 2011). Considering the wide range of services offered to private and commercial consumers today, defining broadband simply as fast transmission speed is no longer adequate. Service areas such as telemedicine, remote education, e-commerce, entertainment and TV streaming, fast videoconferencing, and a whole range of commercial and government-related services

---

<sup>1</sup> Bits and bytes are the most commonly used technical terms related to digital communication and broadband. The following are brief definitions of these terms:

- A bit is the electrical representation of one digit in the binary numbering system used in data processing. A sequence of eight bits forms one byte.
- Kilobits (1kbit = 1000 bits) or Megabits (1Mbps = 1 million bits) is the unit of measure that is commonly used to describe the total amounts of data transported over a communication link, for example downloaded from a service provider. It is therefore a measure of data volume.
- Kilobits per second (1kbps = 1000 bits per second) and Megabits per second (1Mbps = 1 million bits per second) are measures of *data transmission speed*, i.e. how fast a data link is.
- A byte is a sequence of eight bits, needed to represent a single character input from a keyboard, or displayed on a screen, etc. It is normally used in terms of Megabytes (MB) or Gigabytes (GB), etc. to represent memory storage capacities (e.g., on hard disk drives, mobile devices, or USB memory sticks, etc.).
- Based on the above, the relationship between Mbits and MB can be expressed as follows: 1 Mbit = 1/8 Megabytes = 0.125 MB.

require faster speeds, higher data volumes, and improved reliability of service.

In the past, the invention of new services fueled demand for faster speeds. Projecting past experience into the future, there are presently no foreseeable data speed limits to define broadband. The national broadband plans announced by some countries contain benchmarks, at least for rural communications. Canada, for example, which has a vast, sparsely populated area in the north of the country, has defined a minimum general Internet speed of 5Mbps for rural households, and a minimum of 3Mbps for extremely rural settings (Connecting Canadians, 2014) reachable only by satellite. In addition to transmission speed, the UN Broadband Commission added the following two

additional requirements to the definition of broadband (BCDD, 2014):

- A service that is always on (in contrast, for example, to switched and/or dial-up connections, which are temporary)
- The capability to provide multiple services simultaneously

Data transmission speed is not the only objective. Potential users are also interested in the services that any given broadband system can support.

In 2008, the California Broadband Task Force attempted to correlate data speed ranges and supported applications (California Broadband Task Force, 2008). Table 1.1 represents an abbreviated

**TABLE 1.1 Correlation of Data Speed Ranges and Supported Applications**

Data Speed Range	Applications	Data Speed Range	Applications
0.5–1 Mbps	Voice-over IP	10 Mbps–100 Mbps	High-definition video downloading
	Text messaging (SMS)		Low-definition telepresence
	Basic email		Gaming
	Basic Web browsing		Basic medical file sharing and basic diagnostics
	Music download		Remote education
	Low-quality video		Building control and management
1 Mbps–5 Mbps	Advanced Web browsing	>100 Mbps	Telemedicine
	Email with large file attachments		Educational services
	Remote surveillance		Standard and high-definition video broadcasting
	3-channel standard definition TV streaming		Complex gaming
	Large file sharing		High-quality telepresence and video conferencing
	Ordinary telecommuting		High-definition surveillance
5 Mbps–10 Mbps	Single-channel digital video broadcast		Smart building control
	Streaming music		Full high-definition video and video on demand
	Telecommuting (converged services)		High-definition telemedicine and educational services
	File sharing (large files)		Scientific and research applications
	Advanced standard definition video broadcasting/streaming		

Source: The State of California, 2008.



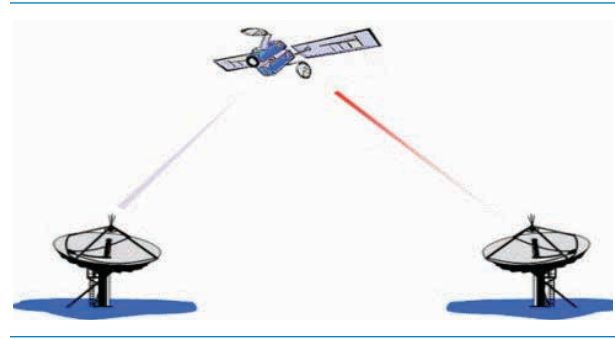
summary of the Task Force's findings, which are still valid today.

In the LAC region, large segments of the population are not even connected in the lowest broadband category listed, which demonstrates once more how the digital divide has widened. To narrow the digital divide, it is vital to pay special attention to underserved communities and to the technologies used for broadband access. The LAC region encompasses enormous social, demographic, and geographic diversity, which poses challenges for the universal introduction of state-of-the-art broadband access. This is especially true in rural areas, where terrestrial telecommunications, such as cable and cellular systems, are often cost-prohibitive. In these cases, telecommunications satellites can successfully complement other technologies. This study explores the advantages of satellite broadband in certain scenarios to develop optimized telecommunications policies, strategies, and technical concepts for universal broadband access.

## Satellite Telecommunications Basics

Satellites are artificial objects intentionally placed into orbit to collect information and for purposes related to communications. They are an integral part of everyday life because they enable important services, such as telecommunications, navigation, TV transmission, security, and reconnaissance missions, to function. According to a 2012 report by the Satellite Industry Association (SIA), more than 50 countries operate at least one satellite (SIA, 2013). This report also points out that more than half of all operational satellites are communications satellites, and more than a third of them are commercial communications satellites. Hundreds of satellites are currently operational, while thousands of unused satellites and satellite fragments orbit the earth as space debris. There are several kinds of satellites, from those designed for monitoring the weather to those designed for military purposes. This study focuses on communications satellites, that is, those with the capacity to transmit telecommunications, especially broadband.

**FIGURE 1.1** The Satellite as Relay Station in Space



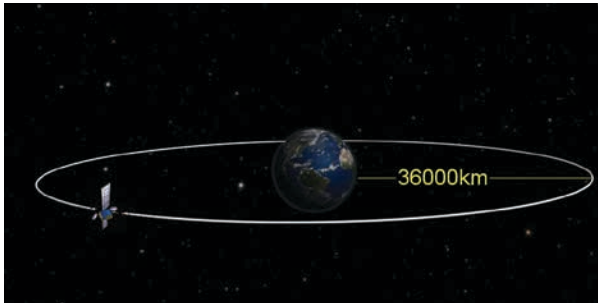
Source: ITSO.

Telecommunications links between remote stations using satellite technology are based on two principles. First, they use narrowly concentrated microwave beams as information carriers, with relay stations located on manmade objects (satellites) orbiting the earth. Satellite transmissions resemble terrestrial microwave links, which bridge distance by using a series of relay towers. Each relay tower receives the signal on one end, amplifies it, and transmits it to the other. A telecommunications satellite is a microwave relay station located not on a tower, but on a spacecraft in orbit (Figure 1.1).

The second principle that has enabled the success of today's telecommunications satellite technology and industry is that there is one orbit around earth where objects move with the same angular speed (that is, the rate at which an object changes its angle in a given period) as an observer on the earth's surface. As a result, from the observer's viewpoint, these objects remain stationary; they do not ascend over the horizon and then descend below it, as all other natural or manmade celestial bodies appear to do. This orbit, called the geostationary earth orbit (GEO), lies about 36,000 km above the equator. Satellites located on this orbit, called geostationary satellites, offer the obvious advantage that the sending and receiving stations on the ground do not need to track them. They are at a virtual standstill (Figure 1.2).

In 1945, Arthur C. Clarke, a science writer, described and patented the idea of using geostationary radio relays to bridge vast distances on earth. The principle he developed continues

**FIGURE 1.2 The Geostationary Earth Orbit<sup>a</sup>**



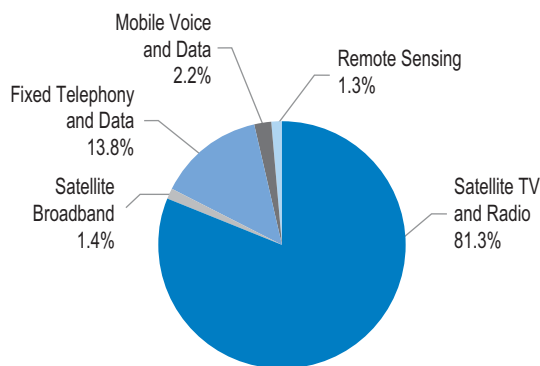
Source: ITSO.

<sup>a</sup> To an observer on earth, the satellite appears to be standing still.

to be the basis for almost all telecommunications satellite systems in operation today. Although space telecommunication has some of its roots in defense-related requirements, most of the systems presently operating are for civilian use and are owned and operated by private companies or consortia.

As Clarke realized, just three satellite relays, positioned in geostationary orbit high over the middle of the three major oceans (the Atlantic, the Pacific, and the Indian Oceans), cover almost all of the habitable land on earth. In the absence of reliable means of terrestrial transmission with large capacity, satellite operators, in particular the Intelsat and Intersputnik cooperatives, focused

**FIGURE 1.3 2013 Worldwide Commercial Telecommunications Satellite Revenues by Service Category (in percent, out of a total of US\$118.6 billion)**



Source: SIA, 2014.

on the provision of transoceanic connections and other applications where substantial geographic obstacles prohibit the use of conventional, terrestrial technology. Until the emergence of satellite technology, copper submarine cables and HF radio were the only means of transoceanic transmission.

Today, telecommunications satellites represent a sizable industry, with several hundred operational geostationary satellites supporting the full spectrum of modern telecommunications services. These include, but are not limited to, radio and television (TV) broadcasting, satellite broadband, telephone calls, wireless, mobile, and cellular network services, and remote sensing (see Figure 1.3). As of November 2014, there were 402 active commercial telecommunications satellites in orbit.

According to Ofcom (2014), global TV industry revenue was approximately US\$401.3 billion in 2013, US\$92.6 billion of which came from satellite TV services. This demonstrates the significant market share of satellites in TV broadcasting. In fact, 81.3 percent of total telecommunications satellite capacity was used for this purpose (Figure 1.3). Revenue from fixed telephony and data services came in second, with US\$16.4 billion coming from global satellite services. Mobile voice and data services generated US\$2.6 billion. Revenue from satellite broadband was US\$1.7 billion. Satellite broadband represents a growing capacity segment for the provision of broadband, Internet, and mobile applications. In that regard, as detailed in SIA (2014), the number of subscribers to satellite-based broadband services globally grew by about 20 percent in 2013.

In addition to the geostationary satellites mentioned above, there are also satellites on non-geostationary orbits used for telecommunications purposes. There are specific roles for broadband services, with pros and cons for each.

## Managing the Resources

The two major physical resources used by telecommunications satellites are the following:

- Those parts of the frequency spectrum allocated to this service by international convention
- The orbital positions occupied by the satellites

Supply in both categories is limited. Resource limitations have a significant impact on the commercial and policy aspects of any satellite-based project.

Telecommunications satellites must share the overall available spectrum of usable radio frequencies with all other space-based services (meteorological, scientific, earth observation services, etc.), as well as terrestrial applications (microwave relay systems, radar, mobile telephones, etc.). To avoid interference between services, ITU member countries have allocated, through a binding international agreement, certain parts of the spectrum to certain services and applications (Radio Regulations, 2012). The parts of the frequency spectrum used by commercial satellite services are C-Band, Ku-Band, and Ka-Band.<sup>2</sup>

The second basic and limited resource, that is, the available number of orbital positions, is even more contested than the frequency spectrum. The several hundred satellites mentioned before, lined up in geostationary orbit, have led to the current situation that satellites orbit at less than a 1-degree angle apart from each other. The signals from these satellites and from the ground stations accessing them would cause extreme interference were it not for the use of different frequencies and sharply pointing antennas toward and by neighboring systems. Moreover, potential interference affects all satellites; it is not limited to satellites in geostationary orbit.

To avoid these conflicts, the ITU has established a set of rules for registration and intersystem coordination. An ITU member administrator can register a satellite on behalf of an operator, using the satellite's technical and operational parameters. Due to the limitation of the orbital position resource, other systems are likely to challenge this registration. The following is a set of rules that apply in such a case:

- A first-come-first-served principle governs positioning in a new, unchallenged position.

- Existing systems and their replacements with the same technical parameters have preference over new systems.
- A registered orbital position that has been unused will fall back into the pool of available positions.
- Systems competing for the same and for neighboring orbital position(s) have to enter into intersystem coordination processes to find interference limiting operating conditions.

However, in practice, an existing system has a stronger position than a new system that has yet to be registered and placed in operation.

## Orbits for Broadband Satellite Systems

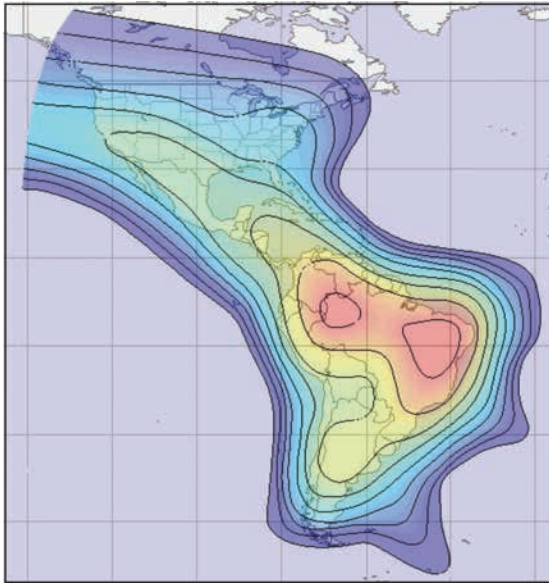
### *The Classic Approach*

As described above, the classic satellite service consists of radio relays (in the form of satellites) in geostationary orbit and their corresponding earth stations on the ground. This basic configuration characterizes the whole range of telecommunication services, including broadband. However, limitations in the frequency spectrum and available orbital positions also limit data throughput capacity and the number of subscribers that can be served. On the positive side is the technical simplicity of this configuration, namely, the virtually stationary satellites and the fact that this concept is technically mature.

To illustrate a geostationary satellite's capability, Figure 1.4 depicts the typical configuration of a transmit-and-receive beam, that is, the areas on the earth's surface that the satellite can serve. The picture shows a specific beam of the Hispasat-1e, with coverage of the Americas. Satellite system operators publish these beam coverage pictures, with the areas of transmit power-and-receive sensitivity levels

<sup>2</sup> C-Band is a frequency range of about 4GHz for signal downlink (satellite to earth), and 6GHz for uplink (earth to satellite). Ku-Band: 11/14GHz, and Ka-Band 20/30GHz.

**FIGURE 1.4 A Typical Geostationary Satellite Beam**



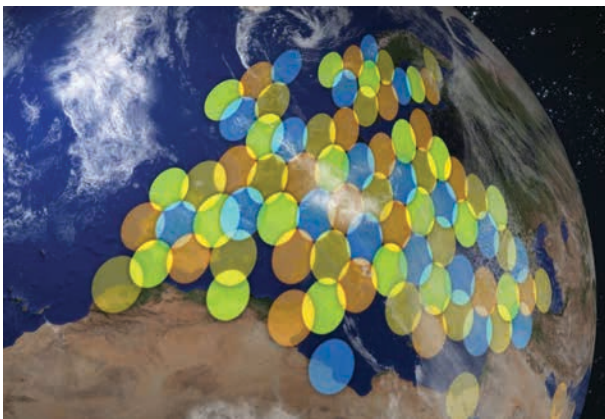
Source: Hispasat, 2015.

identified with contour lines and highlighted in different colors. Beam coverage is also called a footprint.

### **High Throughput Satellites: A New Approach to GEO Broadband Systems**

To overcome the capacity limitations of the frequency spectrum, a new concept for geostationary satellites, specifically for broadband services, has

**FIGURE 1.5 HTS Pencil Beams for Broadband Services**



Source: Sat Sig, 2015.

recently been developed. These satellites, called high throughput satellites (HTS), carry antennas that generate a large number of very small, pointed beams—so-called pencil beams—that are to some extent steerable. These beams carry high-powered signals and are electrically isolated from each other so that the same allocated frequency bands can be used multiple times without causing interference. Most major satellite operators are already operating or are planning to launch HTS satellites. Figure 1.5 shows a typical cluster of pencil beams, in this case from the Eutelsat KA-SAT spacecraft.

### **The Medium Earth Orbit Satellite Alternative**

Internet-based broadband services are services that use TCP/IP (transfer control protocol/Internet protocol), a set of technical rules and parameters governing the exchange and flow of data over the Internet. They are sensitive to the time delay that the signal experiences during transmission. The term for this delay is latency. In simple terms, latency slows down Internet data throughput, and therefore determines “how broadband” a connection can be.

For satellite broadband connections using geostationary satellites, the main reason for signal delay, and therefore latency, is the time it takes the signal to travel more than 36,000 km from a ground station to the satellite and back to the corresponding station on earth. Since terrestrial systems, such as cables and microwave relay systems, do not have to bridge such long distances, their signals are subject to much shorter latencies, resulting in faster transmission speed and data flow.

To alleviate this problem, several satellite system concepts use so-called medium earth orbits (MEO), rather than the GEO systems described above. MEO satellites are not stationary. MEO altitudes are between 2000 km and the GEO at 36,000 km. To enable continuous service, operators must deploy a fleet of several satellites. All ground stations must track the spacecraft, which raises the cost of the earth segment.

Today, the most advanced of the MEO projects in terms of full operational status is the O3b system.



**FIGURE 1.6** The O3b Satellite Configuration



Source: O3b Networks, 2015.

O3b stands for “other 3 billion,” implying that the system is meant for the 3 billion potential users that have no fast Internet access through fiber optics. Figures 1.6 and 1.7 depict O3b’s satellite and orbit configuration, and coverage and service area.

## A Brief Excursion into Technology

### *Subsystems of a Telecommunications Satellite*

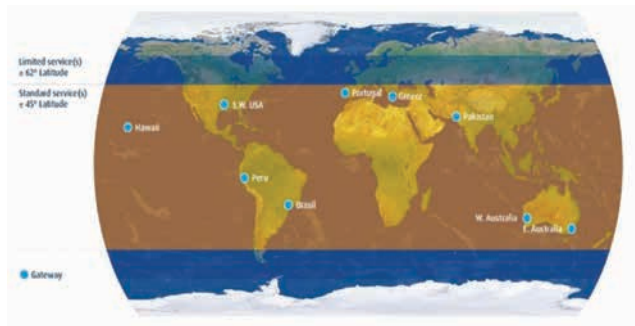
On the main level, a satellite can be divided in two parts. The first is the bus, or platform. It contains all parts needed for the following functions:

- Electric power generation (solar panels and batteries)
- Steering, propulsion, and attitude control (to keep the satellite in its designated orbit station and pointing in the correct direction)
- Monitoring and remote control (to track the satellite, monitor its health, and make changes and adjustments by remote command)
- Housing (to shelter subsystems from the harsh space environment and keep temperatures at predetermined levels)

Typically, major space technology manufacturers offer satellite busses in modular form and in various sizes and electric power supply capacities.

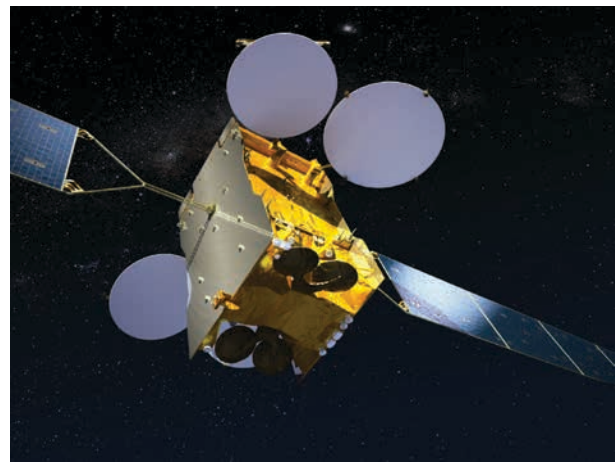
The second part is the payload, which comprises all of the components needed for the telecommunications mission itself, including the following:

**FIGURE 1.7** O3b’s Service Coverage Area



Source: O3b Networks, 2015.

**FIGURE 1.8** Geostationary Telecommunications Satellite



Source: Airbus Defense & Space, 2016.

- Antennas to receive and transmit in one or more frequency bands and to form the beams according to the design requirements
- Receivers
- Transmitters and signal amplifiers

Figure 1.8 is an artist’s rendition of a typical state-of-the-art telecommunications satellite as deployed in orbit.

### *Beams, Footprints, and Coverage*

A satellite radiates radio energy in the form of a lobe, very much like a flashlight, but more pointed. This energy, though not visible, forms a footprint

**FIGURE 1.9** Example of a Satellite Antenna for a Local Hub Station



Source: YouTube, 2015.

on the surface of the earth. The area inside this footprint is its coverage. It defines the area from which stations can transmit to the satellite and receive signals from it. Consequently, this term is a key technical and business characteristic of any telecommunications satellite.

The types of beams used, mainly distinguished by their shape and size, are the following:

- Global beams (with the footprint of the whole earth visible from the satellite)
- Hemi beams (geographically roughly covering a hemisphere)
- Zone beams (roughly half the size of hemi beams)
- Spot beams (covering a country or several neighboring countries)
- Pencil beams (used by the new HTS satellites)

Using the simple comparison with a flashlight again, a smaller beam with a tighter footprint offers higher-power levels on ground. This advantage reduces the size and cost of earth station antennas, increases data throughput, and improves service quality. Moreover, small beams pointed at different places on earth allow reuse of the same frequency

**FIGURE 1.10** Example of an End-User Satellite Internet Station



Source: Home Satellite, 2015.

segment, thus increasing the available spectrum resource.

### **Earth Stations**

Returning to the concept of a satellite telecommunications network as a relay system in space, it is obvious that stations must exist at both ends of the signal paths to and from the satellite to transmit signals to terrestrial communications systems and end-users. These stations, known as earth stations, ground stations, or simply terminals, consist of an antenna (also called a dish) (Figure 1.9), a receiver, a transmitter, and equipment to adapt signals between the terrestrial network and the space transmission path. This equipment includes coders, decoders, satellite modems, and others.

Large earth stations capable of handling high traffic throughput are gateway stations. Large earth stations connect to the national or global Internet backbone network, while smaller stations serve as local hubs, using satellite connections as feeder links to and from a large gateway station. Very small terminals can be installed at end-user premises in cases where satellite broadband signals are directly brought to the end-user.

# The Choice between Broadband Technologies and the Satellite Solution

---

The main transmission technologies for broadband services are: (i) fiber optic cables, (ii) telecommunications satellites, and (iii) terrestrial microwave systems, such as cellular phone systems and broadband wireless access technology. Each of these technologies has strengths and limitations. It is important to understand the strengths and limitations of each broadband medium because lack of broadband access is an impediment in many countries. This is especially true in developing countries, landlocked countries, islands, and developed countries with low population densities.

This chapter addresses the limitations of the various transmission technologies and highlights the scenarios in which satellite broadband is the best alternative for providing broadband connectivity. For example, terrestrial technologies, such as fiber optic cables, require substantial investment in infrastructure and are consequently not cost-effective in regions of low population density. Satellite broadband can play a crucial role in connecting rural areas and areas with low population density where terrestrial broadband is not cost-effective. This chapter will also discuss other media for broadband, such as fiber optic cables and microwave, and will compare them with satellite broadband in different scenarios.

It is important to note, however, that these technologies are not mutually exclusive and that no technology will achieve universal broadband coverage by itself. Depending on the specific requirements of a given deployment, any combination of these technologies can lead to the optimum technical and financial solution.

## Strengths and Limitations of Fiber Optic Cables

Fiber optic cables can provide first-class bandwidth and speed. Many telecommunications companies use them to provide Internet services, cable television signals, and other types of communication in densely populated areas. Some of the advantages of fiber optic cables are their resistance to electromagnetic interference, their lighter weight, their small diameter, and the lower cost of materials compared to older copper technology. Moreover, fiber optic cable systems have a design life of 25 years or more.

Despite these advantages, fiber optic systems are complex and expensive to install and operate. Because of this drawback, fiber optic communication systems are first installed for long-distance applications, such as global and national Internet

backbone networks, where they can be used to their full transmission capacity, offsetting the increased cost.

Prices for fiber optic communications have dropped considerably over the last decade, and the price for installing fiber is more cost-effective than installing the older, copper-based networks in urban and suburban areas. However, cables (and, similarly, terrestrial microwave relay chains) are still expensive to install, they may need protection from accidental or deliberate damage, and they can take considerable time to repair.

When deciding between cable and satellite-based broadband systems, in addition to capacity requirements, the main factors to consider are the following:

- Deployment cost: It is distance-dependent and terrain-dependent for cable systems, while it is fixed for satellite systems.
- Deployment time: It is distance-dependent and terrain-dependent for cable systems, while it is instantaneous for existing satellite systems.

This general comparison does not account for operating expenses. For example, in the case of

satellite broadband, there are further distinctions depending on whether transmission capacity is leased, or a complete satellite system or part of it is purchased.

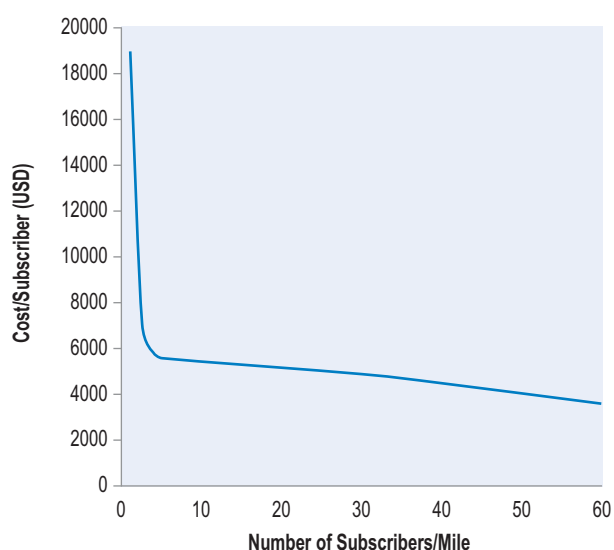
The authors of this study consulted several sources to estimate capital expenditures (CAPEX) for cable deployment and subsequently to determine a range of benchmark criteria for the most economical use of competing transmission media (satellite, fiber optic cable, microwave, or a combination). The price range for cable deployment varied so widely from source to source as to be of questionable use.

Vantage Point Solutions, an engineering and consulting company, has developed a model for cable CAPEX, specifically for rural areas (Vantage Point Solutions). It contains the following considerations for determining CAPEX for cable:

- Along its route, a cable typically picks up customers, either directly or through an intermediary system, such as a local wireless hub.
- A reasonable construction cost comparison figure is therefore the cost of connecting each subscriber to a cable system, as a function of the number of customers per mile of cable constructed.
- Costs for building cable routes range widely based on geography, terrain, soil condition, labor and logistics during construction (Kim, 2012).

Based on the Vantage Point Solutions' results, Figure 2.1 illustrates the trends in CAPEX for cable system deployment. Figure 2.1 shows that when a sufficiently large number of subscribers is linked to the cable (per mile of cable length), CAPEX remains relatively flat, at a value of approximately US\$3,500 or less per subscriber. However, significant changes occur when only a very limited number of customers per cable mile are connected. For example, if there are fewer than five subscribers per cable mile, the cost to link a single customer is prohibitive. This is when implementation of cable systems for broadband becomes economically

**FIGURE 2.1 Capital Expenditures for Cable Deployment**



Source: Vantage Point Solutions, 2015.



questionable, and where other transmission media are called for.

## Satellite Broadband Specifics

As recognized by the Broadband Commission for Digital Development in 2013, “satellite technology plays a key role universalizing broadband coverage, either on its own or as a complementary technology” (BCDD, 2013).<sup>3</sup>

The principal advantage of telecommunications satellites over cable systems is that satellites generally represent point-to-multipoint systems. That is, they do not end at a single, specific point; rather, they can reach all geographic targets within a given footprint. Consequently, establishing satellite coverage over a region instantly establishes the possibility of linking many customers to the broadband and Internet backbone network.

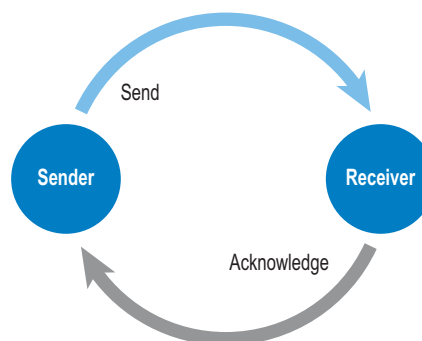
As distinct from other technologies, satellite broadband connections can be set up immediately without large investment in terrestrial infrastructure. Users only need a satellite antenna and a modem to obtain broadband access. Therefore, “satellite can play a vital role in overcoming isolation due to the absence or limited extend of terrestrial infrastructure, thus providing connectivity to unserved and/or underserved regions” (BCDD, 2014: 69).

The use of satellite broadband technology offers the following advantages:

- Generic multi-point capability
- Distance-independent CAPEX
- Fast implementation
- High service reliability
- Low risk of accidental or deliberate interruption<sup>4</sup>

Cable is the preferred medium in densely populated areas because of its superior transmission capacity and cost effectiveness in these cases. In rural settings, however, cable is not cost-effective, and satellite broadband is the preferred medium.

**FIGURE 2.2 Data Transfer on the Internet**



Source: ITSO.

The unique advantages of satellite technology notwithstanding, it has certain limitations, most notably the usable bandwidth (and consequently transmission speed) compared to fiber optic cables. The main disadvantage of satellite technology is latency, which limits transmission speed.

In broadband Internet services, the TCP/IP protocol governs the accurate exchange of data. In general, this protocol includes an acknowledgment process where, after receiving a certain amount of data, the receiving end of data packages must first acknowledge correct reception back to the sender before more data can be sent. As depicted in Figure 2.2, the process is similar to handshaking, or a conversation between sender and receiver. It is not just a one-way, uninterrupted transfer. Consequently, any delay in the acknowledgement will hamper the overall data flow.

The satellite operator O3b, promoting the idea of reduced latencies due to their lower-orbiting

<sup>3</sup> The Broadband Commission for Digital Development was set up by the International Telecommunications Union (ITU) and United Nations Educational, Scientific and Cultural Organization (UNESCO) in response to UN Secretary-General Ban Ki-moon’s call to step up UN efforts to meet the Millennium Development Goals (MDGs). The Commission was established in May 2010, five years after the World Summit on the Information Society (WSIS) and ten years after the launch of the MDGs.

<sup>4</sup> Typical interruptions of terrestrial links, like cables, include accidental damage during underground construction, natural disasters, vandalism and sabotage.

satellites, has calculated that, on average, a geostationary satellite path will add about 500 milliseconds of round-trip latency to any Internet connection. Any signal processing in the remaining network, such as user equipment, servers, fiber optic Internet, and others, adds another 150 milliseconds, leading to an overall round-trip latency of about 650 milliseconds (O3b Networks, 2015).<sup>5</sup>

Using O3b data, an attempt has been made to picture the dependency of data throughput from latency ranges typical for GEO and MEO satellite systems, as well as generic latencies as they occur due to data processing and terrestrial routing, such as over fiber optic cables (O3b Networks, 2015). The results show that using GEO satellites limits data transmission speed well below 100Mbps, twice the amount for MEO systems, while the generic latencies are expected to be in the 0 to 100 milliseconds range, with transmission rates of 1Gbps and above for cables.<sup>6</sup> Moreover, double-hop satellite connections, that is, connections that use two GEO satellites for an Internet connection, thus doubling latencies, will not achieve data speeds envisioned for broadband applications.

## The Role of Terrestrial Microwave Systems

The third broadband transmission technology is terrestrial microwave systems. These are typically used either as relay chains with multiple repeaters, enabling them to bridge long distances, or for a localized distribution of broadband signals within a building, a neighborhood, or in a pattern of cellular areas, as defined for mobile telephone services. These latter applications are commonly called last-mile or local loop connections because they represent the final leg between the larger broadband network infrastructure, the wide area network (WAN), and the end-user.

### Microwave Relay Chains

With respect to network architecture, the use of microwave relay chains duplicates the use of cable

links, because they are mainly point-to-point links, where CAPEX is distance-dependent. Although relay chains may be deployed easier and faster than cable links, especially over rough terrain, terrestrial microwave systems require an unobstructed line-of-sight between stations. Therefore, CAPEX can easily skyrocket when the topography demands a large number of relay stations. Moreover, data transmission capacities are substantially lower than for fiber optic cables, and remote relay stations require local electric power generation, manned operation, and frequent maintenance. In a 2010 publication, Intelsat proposed the idea of using satellite links rather than microwave relays as a more economical solution for backhaul (that is, intermediate links) to and from remote cellular sites in Africa (Analysys Mason and Intelsat, 2010).

### Microwave Last-Mile Applications

Microwave technology for last-mile applications has recently boomed, in particular when fiber optic cable installation to the end-user's premises is cost-prohibitive. Broadband wireless access is the generic term for the following:

- Wireless local loops (WLL): the radio links between a local provider's facilities (routers, links to the broadband backbone network, etc.), and the customer premises equipment (CPE). WiMAX,<sup>7</sup> for example, is a standard used for wireless last-mile connections for up to 1 Gbps

<sup>5</sup> Data transmission throughput (speed) can be calculated for an error-free Internet link as:  $\text{Throughput [bps]} \leq \text{RWIN [bits]} / \text{RTL [sec]}$ , where RWIN is the size of the receive window or buffer, and RTL is the round-trip latency.

<sup>6</sup> This assumes a TCP buffer size of 64KB, typical for older Windows operating systems. Other TCP buffer sizes and/or operating systems can substantially improve the results.

<sup>7</sup> WiMAX (Worldwide Interoperability for Microwave Access) denotes interoperable equipment according to the IEEE 802.16 standard, primarily designed for last mile applications. See WiMAX official page. Available at [www.wimaxforum.org](http://www.wimaxforum.org).

- Wireless local area networks (WLAN): used in homes, offices, and buildings, commonly known as WiFi<sup>8</sup>
- Wireless personal area networks (WPAN): the individual, private network of a single user

The flexibility and relative ease of implementation, high data speed for the designated use, and distance-independent CAPEX within the defined purpose make these technologies serious competitors to the concept of all fiber-optic cables to the end-user. Interoperability of equipment from competing manufacturers is key for a technically efficient service at reasonable equipment cost. Equipment certified to meet the respective standards carries the WiMAX and WiFi logos.

### The Satellite Solution: Network Architecture for Satellite Broadband Service

Although fiber has been the preferred medium for transmission capacity and speed, because of the above-described limitations for the deployment of cable systems, broadband access is a problem still faced by many countries. Incorporating other technologies, such as satellite broadband, can remedy the limitations imposed by terrestrial broadband.

The limitations of terrestrial broadband are particularly evident in developing countries, landlocked countries, islands, and developed countries with low population densities, where the expansion of terrestrial fiber is difficult. The Broadband Commission for Digital Development notes that “nearly one-half of the world’s population lives in rural, hard-to-reach areas, and satellite technology can play an important role in the delivery of broadband services in those areas” (BCDD, 2016: 65).

In this context, the choice of broadband solution depends on geographic, socioeconomic, and cost parameters. An IDB study on broadband in LAC countries concludes that broadband access in the region is not only low in speed, but also expensive for subscribers compared to average costs in

OECD countries (Garcia Zaballos and Lopez-Rivas, 2012). Moreover, the digital divide exists not only between continents, regions and countries, but also between urban and rural populations within countries.

In relation to cost, terrestrial technologies for the provision of broadband are by their technical nature related to substantial investments in infrastructure, and are therefore financially burdened if not cost-prohibited in regions of low population density, especially since the cost is dependent on the number of subscribers. The dichotomy of the large percentage of rural populations versus the high cost of implementing terrestrial broadband systems is the quintessential challenge for the introduction of universal broadband services in regions with low population density. Recurrent and non-recurrent costs for satellite broadband transmission systems are known and constant. Hence, the key questions leading to the selection of suitable alternative broadband facilities in LAC countries are: (i) what is the population density of the LAC region, and (ii) how large is the population segment living in rural settings? The answer to these questions will determine the need to implement alternative broadband facilities.

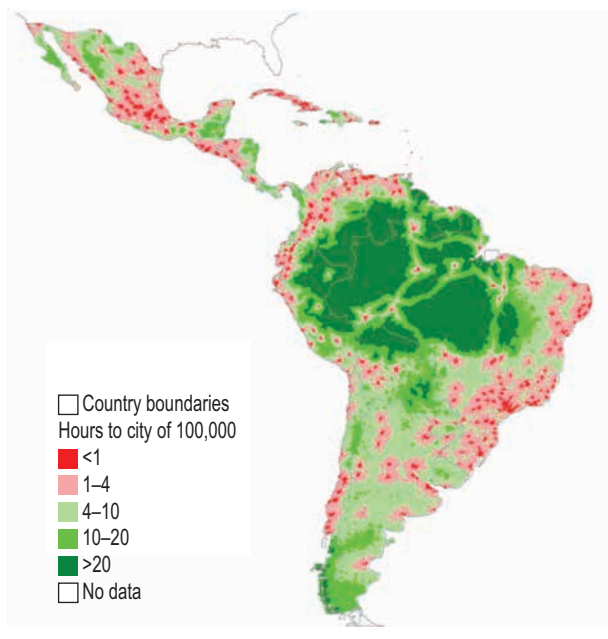
The World Bank published the following data in 2005 on the population of the LAC region (Chomitz, Buys, and Thomas, 2005):

- 13 percent of the LAC population lives in ultra-rural settings of <20 people/km<sup>2</sup>
- 25 percent of the LAC population lives in rural settings of <50 people/km<sup>2</sup>
- 46 percent of the LAC population lives in rural settings of <150 people/km<sup>2</sup>

Distance is also a key criterion for the broadband technology selection, because of its relation to cost. According to the same study (Chomitz, Buys, and Thomas, 2005):

<sup>8</sup> Wi-Fi denotes interoperable WLAN equipment based on the IEEE 802.11 standard. The Wi-Fi Alliance coined the term. See [www.wi-fi.org](http://www.wi-fi.org).

**FIGURE 2.3 Imputed Travel Time to Nearest City of 100,000 People**



Source: Chomitz, Buys, and Thomas, 2005.

- 18 percent of the LAC population lives more than four hours from a large city
- 42 percent of the LAC population lives more than one hour from a large city

Figure 2.3 shows the population of LAC in terms of travel distance from urban centers (Chomitz, Buys, and Thomas, 2005).

Fortunately, telecommunications satellite technology can complement terrestrial networks, as they can provide broadband access almost instantaneously and in any geographic location, reducing investment requirements largely to terminal and end-user equipment. However, satellite-based systems have well-known limitations, notably in terms of capacity. Fiber optics offer vastly superior bandwidth and, therefore, transmission speed, and lower latency. Even with these potential drawbacks, there are a number of strong advantages to using satellite as a medium to bridge the digital divide in rural and low population-density areas. Thus, telecommunications policies, strategies, and technical concepts should incorporate satellite-based broadband access.

The LAC region is a prime candidate for investment in satellite broadband, either by itself or as a complement to the expansion of broadband. The selection of optimum network architecture is critical to the successful and cost-effective implementation and operation of a satellite-based broadband network. Network architecture alternatives include the main options of combining satellites, earth stations, and terrestrial transmission facilities into a functioning system meeting specific service demands and cost constraints. The following sections will outline these options.

### ***Direct-to-End-User Satellite Broadband Systems***

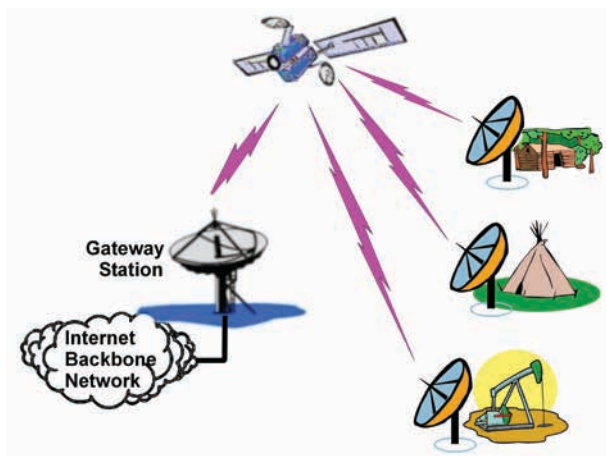
In this network architecture, end-users have direct access to broadband Internet data provided via satellite. Their on-premises terminal equipment is similar to that shown in Figure 1.10 on page 8. The gateway station is typically located near an urban center with access to broadband facilities via fiber-optic cable, that is, the Internet backbone network. End-users access the satellite signals directly, using very small aperture antennas and a satellite modem box in their homes or offices.

A number of operators have been providing Internet services directly to end-users for years. When the service uses conventional geostationary satellites, it is expensive and data transmission speeds are quite limited compared to cable-based broadband. However, thanks to recently deployed HTS and MEO satellite systems, this technology has been revolutionized.

### ***Satellite Links as Feeders to Remote Hubs***

In addition to the stand-alone networks described above, satellite technology can expand existing broadband networks, particularly in the LAC region, where broadband cable systems have emerged in urban areas. To expand these networks in a technically efficient and cost-effective manner, a combination of satellite technology and terrestrial microwave systems can be used. In this concept, the satellite

**FIGURE 2.4** Direct-to-End-User Broadband Network via Satellite



Source: ITSO.

link can be a bridge between any sizable broadband community and the Internet backbone. Microwave links to user premises or by cable can establish local and last-mile connections in cases where the proximity of end-users to the local hub station warrants the cost of implementing fiber optic systems.

As pointed out in a study by Analysys Mason and Intelsat (2010), the advantages of using a satellite-based backhaul in combination with local distribution by microwave are the following:

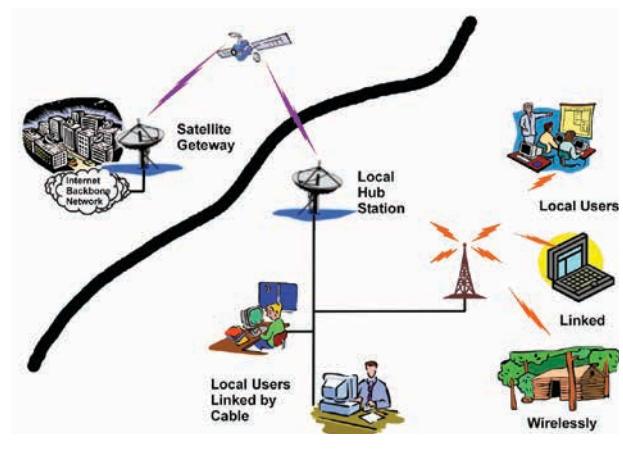
- Minimal required infrastructure and related costs
- Rapid deployment
- Coverage of large service areas with a single satellite beam

In contrast, using microwave relay chains for backhaul purposes would require a large number of repeaters to serve a remote area. It would have the same disadvantages as cable systems, that is, construction cost is distance-dependent.

### Combining Alternative Media

From the above, it is evident that the three basic transmission media available for bringing broadband access to the LAC region are not mutually exclusive. The challenge is to find the optimum

**FIGURE 2.5** Satellite Link as a Feeder for Local Broadband Distribution



Source: ITSO.

combination to use in each application scenario to the maximum benefit of the end-user in terms of (i) service quality, (ii) rapid implementation, and (iii) reasonable and affordable cost.

With this threefold paradigm in mind, network architecture would point to the following deployment scenarios, depending on population density of the targeted end-user communities. However, these are general, non-quantified deployment concepts and alternatives, and each case needs to be evaluated and tailored to the local circumstances.

Scenarios 1-4 below represent different populations and living environments, from highly dense to extremely rural. In urban and suburban settings, fiber optic cable connections are expected to dominate the last mile to the end-user, with BWA systems being an alternative. Service providers are expected to have existing access to the Internet backbone.

When the setting is sparsely populated and rural, satellite broadband is a more attractive option because of its strengths in this area. Satellite broadband can be used either as backhaul and feeder to local service provider facilities or as a direct to the end-user satellite broadband service. In extremely rural settings, direct satellite broadband remains the only technically and financially reasonable solution (see Figures 2.4 and 2.5).



### Scenario 1 Densely Populated Urban/ Suburban Area

- Distance to existing service provider facilities, and the Internet backbone network is short. Broadband generally serves the region.
- Connection of local service provider to the Internet backbone by existing broadband network.
- End-user access alternatives: fiber optic cable, broadband wireless access, cellular wireless system.



### Scenario 2 Remote Village

- Remote village, larger settlement, or cluster of houses with no broadband links.
- Connection of local service provider to the Internet backbone by satellite.
- End-user access alternatives: broadband wireless access, direct satellite broadband.



### Scenario 3 Remote City or Town

- Distinct area of higher population density, remote from the Internet backbone network, and underserved by broadband. Typical of a small city or rural town.
- Connection of local service provider to the Internet backbone by satellite, fiber optic cable, and microwave relay chain.
- End-user access alternatives: broadband wireless access, cellular wireless system, cable.



### Scenario 4 Spread Out, Remote Settlements

- Very remote, spread out settlements, no distinct sizable clusters, native villages, single farms, natural resource sites, etc. No, or only rudimentary, telecommunications exist.
- End-user access alternatives: direct satellite broadband.



Source: ITSO.

## Satellite Broadband in Light of the Value Chain and Business Models

While the above-described network architecture examples focus on the technical and operational aspects of network elements, there are also important business aspects related to the choice of broadband technologies. In principle, the value chain of the telecommunications market consists of three elements:

- Element 1: Basic network infrastructure, that is, the provision of existing or newly built technical facilities
- Element 2: Network operations, that is, the addition of active technical systems to the basic network infrastructure, and the continuous operation
- Element 3: Service provision, that is, the supply of services to make network capabilities available to markets

Element 1 is a prerequisite for Element 2, and Elements 1 and 2 together are prerequisites for Element 3. While large telecommunications companies have been covering all elements of the value chain, emerging competitors typically focus on a specific element, such as service provision using existing technical facilities provided by others. Nevertheless, business models comprising any combination of the value chain elements, provided by the public sector, private companies, or public-private partnerships, have been developed (European Commission, 2015).

With respect to broadband access in rural areas of the LAC region, it is important to pay attention to building and operating the basic network

infrastructure, because it may face one or more of the following challenges:

- The basic network infrastructure does not exist or does not meet the technical standards required for broadband.
- Terrestrial network infrastructure is expensive to establish. Therefore, private CAPEX investment is difficult to obtain.
- The targeted markets and communities are relatively small compared to urban and suburban areas. They are therefore not attractive to private investors.
- The network infrastructure is therefore dependent on public funding.
- It takes several years to establish basic network infrastructure. This will widen the digital divide even further.

When a country or a region faces any of the five challenges mentioned above, satellite technology could be an ideal solution and could contribute to narrowing the digital divide. The last challenge makes it evident that establishing basic network infrastructure should be as efficient and as fast as possible in order to address disparities in broadband access.

Satellite broadband technology offers unique advantages over all other media, spanning several or all elements of the value chain. Existing satellite systems and those planned for deployment within the near future can provide the basic infrastructure, network operations, and services required for broadband in the LAC region. They would therefore positively address all of the critical categories listed above. Moreover, CAPEX funding for these systems is not an issue because they are already funded and operational, under active procurement, or scheduled for launch.





# 3

## The Provision of Satellite Telecommunications Services

---

**T**oday, a number of companies with diverse characteristics and business approaches are providing the satellite transmission capacity required for the various broadband network architecture models. They include companies operating globally, regionally, and domestically. The latter may also target markets adjacent to their primary markets.

This chapter introduces the key satellite operators in the region and their current or planned investment in spacecraft dedicated to broadband. It also reviews the pros and cons of domestic satellite systems and the cost factors in satellite procurement.

### History and State of the Industry

Following the technological development of telecommunications satellite technology in the United States and the Soviet Union in the 1960s, the need to achieve widespread access led to the founding of the International Telecommunications Satellite Organization (Intelsat) as an international, intergovernmental cooperative. On a smaller scale, former Soviet-bloc countries formed the Intersputnik organization. These consortia focused primarily on international voice, TV, and data services. Later, their businesses expanded to include the provision of domestic services. A number of other international, intergovernmental cooperatives, such as

EUTELSAT, INMARSAT, and ARABSAT, emerged in subsequent years.

As the industry matured in the 1980s and 1990s, the privileges enjoyed by these organizations as intergovernmental entities were no longer politically and economically justifiable. Deregulation and privatization in satellite telecommunications followed the same trends as in the telecommunications industry as a whole. The deregulation and privatization that took place in the late 1990s and early 2000s led to the creation of numerous private satellite-operating companies that competed with each other. Moreover, the entry of private equity capital caused mergers and acquisitions among the largest operators, which continue to dominate the global market. In addition to the big players, a substantial number of smaller satellite operators have emerged, primarily targeting regional and domestic markets or specific services. In addition, various countries have procured and are operating their own domestic systems, often with strong government support or sponsorship.

The increasing demand for satellite transmission capacity has also spawned healthy growth in related manufacturing and service industries. The Satellite Industry Association (SIA) reports that globally, approximately 1200 satellites are operational today, with more than 50 percent of them dedicated to telecommunication services and

40 percent to commercial services (SIA, 2014). Moreover, satellite industry revenues have almost tripled, from US\$74.3 billion in 2004 to US\$195.2 billion in 2013.

The second most dramatic change in the industry is the trend toward vertical integration experienced in almost all companies. Prior to deregulation and privatization of the satellite industry, operators focused primarily on the provision of transmission capacity. Today, their businesses generally offer a wide range of services along the value chain, including implementation and management of whole end-to-end telecommunications systems and turnkey solutions.

In the LAC region, Embratel is a typical example. It began with a limited mission as Brazil's international long-distance carrier company. Since then, it has evolved into a full-service telecommunications company, operating domestic satellites, all-digital cable and microwave facilities, and even TV content ownership and distribution (Embratel, undated).

A recent report by Euroconsult identified LAC as a region with a substantially higher compound annual growth rate (CAGR) of 8 percent, as compared to the global average of 5 percent. Future growth rates of 10 percent CAGR are expected over the next decade (Euroconsult, 2015).

## How to Procure Satellite Transmission Capacity: Lease vs. Purchase

From the previous overview of satellite operators, it is evident that private, commercial, internationally operating companies provide the vast majority of total satellite capacity over the LAC region. Nevertheless, as the examples of Venezuela (Simon Bolivar Satellite) and Bolivia (TKSat-1) demonstrate, procuring domestic satellites (DomSats) with government involvement continues to be an attractive option.

### Multiple Mission Systems

Space technology covers a wide spectrum of applications. Some countries have combined

commercial telecommunications services with other applications, particularly those of interest to the government and military communities, creating multiple-role satellites. Examples of noncommercial applications include remote sensing and earth observation, military secure communications, emergency communications, radar, and others. Consequently, reasons other than performance, cost, and commercial payload can be determining factors for domestic satellite procurement.

In the case of Venesat, the Venezuelan domestic satellite system, Bolivar-1 is a telecommunications payload. Two additional satellites that Venesat ordered from the Chinese manufacturer are for remote sensing and earth observation missions.

### Technology, Knowledge, and Industry Promotion

Another argument frequently used to justify the procurement of domestic satellites for all kinds of applications is the transfer of technology and knowledge from the foreign manufacturer to the domestic industry and academia. Manufacturers purposefully include domestic companies and scientific institutions as subcontractors in their bids and proposals.

An example of this technology transfer is the Nahuelsat-1 project for Argentina in the 1990s. The European space industry initiated this project, which helped establish space technology in Argentina. Argentina subsequently built ARSat-1, the first domestically produced telecommunications satellite in Latin America.

### National Considerations and Politics

Independence from third parties is an additional argument for DomSat systems. In communications, governments might want to be independent to avoid a situation in which third parties could shut down a satellite telecommunications system to exert political pressure. Although such cases have been extremely rare, they are not unheard

of.<sup>9</sup> In addition, some governments have used domestic telecommunications satellite projects politically to boost national pride and patriotism.

### *System Cost Considerations*

It is not easy to counter the above-described arguments in favor of DomSats with technical, operational and cost-related facts provided by commercial satellite providers, because these arguments are political in nature. However, domestic satellite systems have a price, which countries can compare to the price of leased commercial capacity.

The following case provides an example of the costs involved. In an interview for this study, one satellite provider that operates internationally stated that it recently sold a satellite at a price per transponder of approximately US\$3 million, delivered in orbit. That is, the price included launch, testing, and launch insurance (Interview with ABS Ltd., November 18, 2014). The satellite in question uses the latest advances in technology, particularly those that reduce the satellite's weight, a critical factor for reducing launch costs. Thus, the approximate cost of a state-of-the-art telecommunications satellite is US\$3 million per transponder.

This cost can be compared to the prices paid by Latin American satellite companies for transponders. Following are the number of transponders procured and the prices paid for them:

- Simon Bolivar-1 (Venezuela) 28 transponders  
Delivered price of US\$406 million  
Price per transponder: US\$14.5 million
- TKSat-1 (Bolivia) 30 transponders  
Delivered price US\$300 million  
Price per transponder US\$10 million

As these examples demonstrate, despite the favorable contractual terms of the two DomSat

procurements, the premium price paid far exceeded what commercial operators expect to pay today.

### *Lead Times, Incremental Growth, System Design Life, and Other Factors*

These three criteria—lead times, incremental growth, and system design life—are related to timing. Commercial satellite operators attempt to achieve high utilization rates as soon as a satellite becomes operational. Industry observers anonymously agree that transponder utilization has substantially increased since the deregulation and privatization era in the early 2000s, due to favorable regulation and competition. The biggest global satellite operators presently claim utilization/fill rates of approximately 80 to 90 percent (Intelsat, undated). However, the extent to which all fully paying customers achieve these fill rates is unclear.

These utilization rates notwithstanding, large commercial satellite operators tend to have sufficient transmission capacities available to meet any initial demand for new domestic requirements. In addition, due to their ongoing procurement initiatives for new capacities, they can meet additional future demand. Consequently, countries can take up leases from commercial operators in increments as demand warrants, with very short lead times before initial service commencement.

By contrast, lead times for the planning, procurement, and deployment of DomSat systems are typically several years between the initial system definition phase and the beginning of the system's operational phase.

Regardless of whether a country leases capacity or purchases a DomSat system, modern geostationary telecommunications satellites have a typical design life of 15 years or more. Consequently, at about 10 years into the operational lifespan of a

---

<sup>9</sup> The satellite communications of a country under economic sanctions was temporarily affected by another country that exerted pressure on the satellite operator. In another industry sector, the reduction of the supply of natural gas to an Eastern European country was used as a political instrument.

DomSat system, the country must make policy, budgetary, and technical decisions concerning the replacement of an existing system. Commercial satellite operators have replacement and expansion plans for their fleet of spacecraft as part of their business and deployment plans.

### ***Sparing, Replacement, and Insurance***

Although they use highly reliable technology, some telecommunications satellites have had catastrophic failures, including missions that have prematurely ended in a complete or large-scale departure from the intended goal. Statistically, these failures are most likely to occur during rocket launch or in the first phase of deployment into orbit and testing. The insurance industry estimates that, on average:

- 38 percent of failures are related to the launch vehicle, that is, the rocket
- 45 percent occur during the first two months in orbit
- 17 percent occur during the rest of the first year in orbit (Market Update Kunstadter, 2014).

Launch insurance is typically the third-largest expense in a satellite procurement, after the spacecraft and the launch. While some large satellite operators opt for self-insurance, smaller companies or projects must purchase insurance because financially they could not survive a catastrophic loss. Presently, the typical insurance premium for the launch and the first year of operation in orbit is 6 to 15 percent (SpaceNews, 2012). However, insurance premiums are subject to large fluctuations.

In addition to insurance, satellite operators protect against failures through sparing and replacement strategies. These can be contractual arrangements with the manufacturer of the satellites and the launch vehicle provider for favorable terms for equipment substitution, warehousing of whole, spare satellites, critical, long-lead replacement components, or the ultimate but very costly alternative of launching spare satellites into orbit.

### ***Ground Control***

Satellites require extensive tracking, monitoring, and control. Ground stations do this, which typically add substantially to the CAPEX of a satellite project. For example, for Venezuela's Venesat family of three communications and earth observation satellites, the cost of the required ground facilities is reportedly US\$165 million.

### ***Managing a Domestic Satellite Project***

According to the authors' past experience with satellite procurement, particularly in developing countries, it is clear that the expertise required to manage such complex projects is lacking at the local level. Therefore, countries should consider employing reputable outside advisors to represent their interests rather than a highly skilled and experienced group of suppliers and vendors.

### ***Regional Consortia***

In the early 1990s, the Andean Association of Telecommunications Companies (Asociación de Empresas de Telecomunicaciones de la Comunidad Andina, or ASETA), an international organization representing companies from Bolivia, Colombia, Ecuador, Peru, and Venezuela, attempted to buy satellite transmission capacity in bulk for redistribution to member countries. At a time when there were few satellite operators and those that existed only provided satellite transmission capacity without complete end-to-end solutions, this approach seemed advantageous and cost-effective. However, considering the advances in the commercial satellite operator market and the trend toward vertical integration, there is no longer room for an additional layer consisting of an international consortium in the value chain. In other words, in a market based on mature technology with substantial growth in supply and demand, there is no longer any need for intergovernmental operational involvement. With respect to telecommunications, multinational integration occurs throughout the

LAC region through multinational media distribution and the Internet.

## Cost, Pricing, and Related Information

The following overview of cost and pricing is a compilation of information gathered from interviews with industry executives and extensive research. The figures quoted are estimates and average values. Actual figures may vary substantially, based on regional market trends, technical parameters, bandwidth increments, length of the lease, and other factors.

- Global average price per year of a 36MHz satellite transponder: US\$1.62 million
  - Most expensive region: Europe (US\$3.2 million/year)
  - Least expensive region: South Asia (US\$1 million/year)
  - Profitability threshold: US\$1 million/year (SpaceNews, 2009)
- Converted to monthly charges, these figures amount to a range of approximately US\$2,300 to US\$7,400 per MHz per month
- Pricing benchmarks for the new generation of HTS Satellites specifically designed for broadband presently range from US\$600 to US\$1,000+ per Mbps per month (Interview with Timothy Shea, APSTAR/ATP Satellite, undated)
- Launch costs per kg of satellite mass to GEO: US\$20,000 to US\$30,000
- Range of insurance rates for launch and first year in orbit: 6 to 15 percent of insured value
- Cost per transponder delivered in orbit:
  - Experienced large satellite operator: US\$3 million or more
  - Government DomSat projects: US\$10 million
- Satellite design life: 15 years or more
- Average data rate per 36MHz transponder:<sup>10</sup>
  - Conventional GEO satellites: 40 to 100Mbps
  - HTS transponders: 140Mbps and more

## Reducing Initial Costs and Risks

When buyers are shopping for satellite transmission capacity is the appropriate time to negotiate a cost reduction with potential satellite capacity operators. The World Teleport Association (WTA) has published a buyer's guide for satellite capacity. It includes the following advice (World Teleport Organization, 2015):

- Negotiate with different vendors, and let them know that you are doing so.
- Develop a plan of incremental increase in the capacity used, based on expected business growth. Start with small bandwidth segments to improve your initial business case.
- Offer a revenue sharing or pay-as-you-go agreement. This is a modification of the incremental increase strategy, and less commonly used. However, it resembles a success-based compensation, and may be attractive to a satellite operator who wants to enter a particular new market segment.
- Negotiate pre-emption and substitution conditions in case of a catastrophic satellite failure.
- Negotiate terms based on length of the lease. In some cases, longer lease times offer substantial price reductions.
- Search for capacity that has been unused for a long time, or is in any case inferior, as long as it can support your service.
- Negotiate an initial free-of-charge period. This is a common means, often supported by satellite operators, to promote and support new service and projects.

<sup>10</sup> Roughly estimated by applying uplink signal-to-noise ratios provided by ViaSat, Inc. 2012 for their consumer broadband service. In regards to Shannon's Theorem, see [http://wildbluetools.com/content/FS/50/52/003\\_SVTDataBackground.pdf](http://wildbluetools.com/content/FS/50/52/003_SVTDataBackground.pdf).

## SUMMARY AND KEY FINDINGS

The following is a summary of the key findings in this chapter:

The satellite telecommunications industry is expected to experience continued healthy growth rates. Demand for satellite telecommunications in the LAC region is expected to grow faster than the global average, with a compound annual growth rate of about 8 percent.

Satellite operators have been following a trend of vertical integration, expanding along the value chain into managed services, including services to end-users.

There are four global satellite service providers and a number of regional providers active in the LAC region.

All of the major satellite operators have incorporated broadband into their strategies, and have ordered or already deployed high-throughput satellites (HTS).

The company O3b has established a medium earth orbit (MEO) system specifically targeting broadband markets in rural and/or remote areas.

In addition, some LAC countries have opted to build domestic satellite systems (DomSats) under government sponsorship.

The reasons for building DomSat systems are political and strategic. They include:

- The ability to have multiple-mission systems
- Transfer of technology and knowledge and industry promotion
- Independence from third parties
- National political considerations

The commercial satellite industry cost per transponder unit delivered in orbit is approximately US\$3 million.

Based on economic and operational business decisions alone, the procurement of government-sponsored DomSat systems should be carefully compared to the cost of leasing commercially available capacity.

If the decision to procure a DomSat system is made, it is highly recommended that the buyer secure expertise that is independent from manufacturers and suppliers.

When initially negotiating the lease of satellite capacity, countries should endeavor to reduce the cost.



# 4

## The Implementation of Satellite Broadband Services

Today, satellite signals that support broadband services are available in all parts of the Latin America and Caribbean (LAC) region. In addition, telecommunications policy and regulation are generally supportive in all LAC countries. This chapter discusses satellite broadband from the standpoint of the end-user.

In this study, the terms “user” and “end-user” refer to a residential, business, institutional, or government entity that uses the services for its own purposes and does not resell them. End-users have different interests, demands, and challenges and are not necessarily interested in satellite technology per se, or the service delivery mechanism. They are primarily interested in ensuring that they have access to state-of-the-art telecommunications quality at an affordable price. Although the information presented here is applicable to all socioeconomic groups, it focuses primarily on the rural and remote end-user, where satellite broadband is the preferred transmission technology.

From the end-user’s perspective, a broadband service must encompass the following five basic elements:

End-users require these service characteristics to be provided by the Internet service provider (ISP),<sup>11</sup> the entity along the value chain with which they interface directly. The ISP plays a crucial role in ensuring end-users’ quality of service (QoS). Because of the central role played by ISPs,

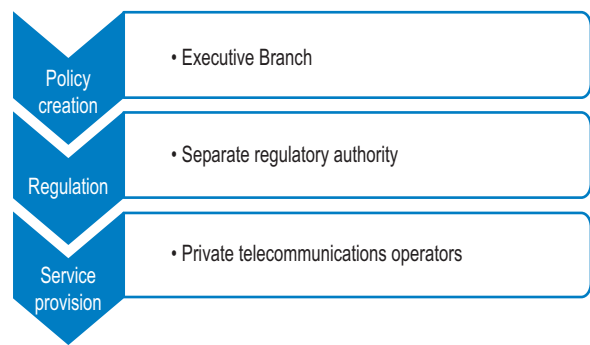
Value	It should add value to life and work.
Affordability	It should be affordable.
Usability	It should be available whenever needed.
Maintainability	Technical support should be available to restore service whenever needed.
Robustness	Its performance should be predictable under conditions that could degrade or otherwise adversely affect service delivery.

government policy and regulations should focus on ISPs by introducing and monitoring QoS standards and defining public service obligations with regard to rural broadband to guarantee country-wide access to broadband and narrow the digital divide that exists between urban and rural areas.

With these principles in mind, there are important factors from the end-user’s perspective that should be taken into account when planning for the initial deployment and sustainable operations of satellite-based Internet broadband services. These include policies and regulations, particularly those that address the challenges of providing broadband to rural areas. Other important considerations

<sup>11</sup> Satellite Internet service providers are businesses and organizations that provide end-users with internet and other services. Annex II contains a full list of ISPs. For the purposes of this report, ISPs refer to satellite internet providers.

**FIGURE 4.1 Institutional Framework for Implementing Broadband Strategies**



Source: ITSO.

when designing a system that ensures end-user accessibility include installation and maintenance, electrical infrastructure, renewable energy solutions for broadband, and safety and security.

Service-level arrangements (SLAs) provide the framework for ensuring robust and reliable broadband service beyond initial deployment, by defining the responsibilities of the ISP and the end-user and detailing the scope and quality of the services. The satellite broadband equipment required at the end-user's premises, as well as the ISP equipment needed to support a broadband network, must also be carefully considered. The technology alternatives chosen also affect end-users.

### Policy, Regulation, and Broadband Service Stakeholders

A clear and focused broadband strategy that will effectively reach end-users requires a solid and detailed institutional framework and a holistic vision for implementation. International best practices show that these attributes accelerate infrastructure rollout and stimulate the development of new digital goods and services. Implementation of a clear strategy with an effective institutional and regulatory framework results in lower prices, better QoS, increased investment, and faster technological innovation.

As can be seen in Figure 4.1, a top-down approach generally determines the institutional

framework for implementing broadband strategies. National governments develop the policies and guidelines necessary for implementation, such as national broadband plans and the provision of ICT services for sustainable development.

A clear and focused broadband strategy is often part of a national broadband plan (NBP). Although national regulatory agencies (NRAs) oversee NBPs, they are usually a product of coordination between several government sectors, which try to implement realistic goals and monitor the plan's success (OECD, 2011). Currently, over 140 countries have broadband plans in place. If used prudently, the NBP can be a catalyst for cross-ministry and cross-sector collaboration, which is key to the development of broadband (NYS Broadband, 2014).

To promote a successful NBP, a country needs to invest in both the demand and supply side of the equation. To address supply, governments should invest in the expansion of broadband infrastructure to underserved communities. However, due to the interdependence of supply and demand for broadband services, governments must also ensure that people will want to use these services. They can do this by making the services affordable, increasing digital literacy, and ensuring that there is relevant local content available.

Once a strategy is established, it is the responsibility of the regulatory authorities to enforce the policies and regulations approved by national governments. These authorities must also regulate the actions of privately and commercially operated telecommunications companies who are responsible for network operation and the provision of services. Regulation of ICTs is important because it is a mechanism to ensure that:

- There is cooperation in a competitive environment, which ensures that there is a level playing field between unequal entities in the marketplace;
- All equipment suppliers are treated equally, especially when the market is dominated by a single buyer with strong pre-existing relationships with suppliers; and



- All customers receive an adequate response when they voice their complaints and interests (ITU, 2012).

Regulators must establish several policies. For example, countries must regulate the spectrum to secure interference-free operations. The ITU defines worldwide standards for spectrum allocation to:

- Promote efficient use of spectrum and orbit resources;
- Ensure that newly introduced systems and applications do not affect those already in existence; and
- Facilitate worldwide spectrum harmonization (ITU-R, 2012).

National governments are responsible for adopting the ITU's guidelines for spectrum allocation and regulation. Once again, the NRA carries this out and ensures that the services allotted by the ITU do not interfere with national services to prevent interference in the national territory (ITU-R, 2015).

Moreover, through a universal access and service strategy, governments can promote broadband penetration in rural and remote locations. Governments use the terms “universal access” and “universal service” in a wide variety of contexts to describe or demonstrate objectives and policies that they implement to ensure that all citizens have access to the benefits of modern economic life. Although there is no one-size-fits-all framework to achieve this, it is important that countries take a holistic approach to achieving universal access and service (UAS), primarily by ensuring that UAS policies are properly formulated and given space in national policy on the institutional framework for telecommunications regulation.

In addition, through licensing, the regulator can ensure easy access to the market by providing general authorization regimes for electronic communications networks and service providers. The objective behind licensing is to allow operators and service providers to use frequencies under certain

conditions, such as standards of service, efficient use of the spectrum, and avoidance of interference and overloading. Licensing also ensures a competitive market where all service providers are equal and can easily enter the market (ITU-R, 2015).

As stipulated by the ITU, “No transmitting station may be established or operated by a private person or by any enterprise without a license issued in an appropriate form and in conformity with the provisions of these Regulations by or on behalf of the government of the country to which the station in question is subject.”<sup>12</sup>

The primary components of satellite licensing are spectrum allocation to minimize interference and public safety regulations. Public safety regulations cover not only the appropriate uses of fencing, secure areas, and warning signage; they also require operators and installers to have adequate training and that the design parameters do not allow transmissions to exceed appropriate levels.

It is evident that policymakers and regulatory bodies play a key role in establishing a favorable policy framework. When it comes to the availability, quality, and cost of broadband services, ISPs also have an important role to play. There are typically a number of additional players involved, who are part of either technical network hierarchy or policymaking, regulation, financing, or customer advocacy. Broadband service stakeholders fall into two groups:

The first group of players consists of the following:

- Cross-sectoral policymakers (telecommunications, health, education, economy, defense and security, agriculture, etc.)
- National regulatory agencies
- Sources of financing and investment from the government and the private sector (government telecommunications funding, banks, private investors, etc.)

<sup>12</sup> See [http://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports\\_RegulationBroadbandSatellite.pdf](http://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_RegulationBroadbandSatellite.pdf).

- Consumer interest groups, foundations, rural development cooperatives, and other representatives of civil society

The second group may include the following:

- Local ISPs that provide services to end-users
- Local network operators (if different from the ISPs) that lease their technical facilities to ISPs
- Satellite broadband service operators that lease satellite access to local network operators or ISPs
- Systems operators providing the transmission capacity in space
- The Internet backbone operators that provide global Internet connectivity

Figure 4.2 illustrates all of the stakeholders involved for each individual project.

Together, with a diverse set of interests, they form the stakeholders for each project. While each stakeholder has a certain influence and interest on its own, none of them can act independently from any of the others. Although because of their association with the government policymakers and regulators would appear to have more weight than the other stakeholders, the government can only

successfully apply its influence and power if the other stakeholders continue to be interested and to cooperate on a given project. Therefore, the main goal of policy and regulation is to create an environment where the interests of all stakeholders are balanced and applied strictly in the interest of the broadband end-user.

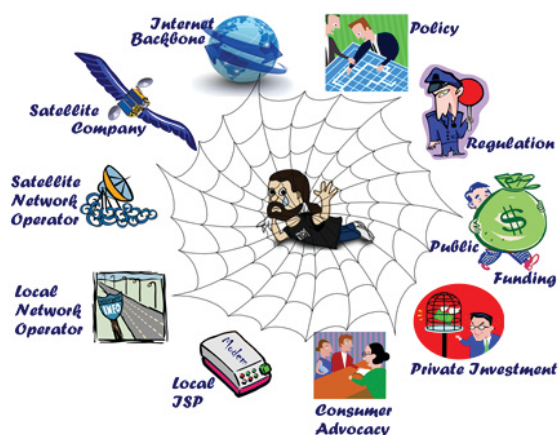
When endeavoring to increase broadband access, the country, region or, subregion in question should undertake a self-assessment of digital maturity. By answering the questions below, a country can discover the degree of its digital maturity, particularly compared to known standards set by other countries, or average global statistics:

- How much emphasis does the government place on prioritizing ICT? Does it have a digital development strategy and plan?
- How committed is the government to the rapid implementation of its digital strategy, for example, through financial involvement?
- Does the government use broadband services? If so, to what extent, and how developed are these services?
- What digital services does the public sector offer its constituents?
- To what extent can the public participate in formulating digital plans and policies?
- How accessible and transparent is policy and regulatory information?
- To what extent is the country promoting ICT to improve the economy's competitiveness?

These questions do not necessarily determine the state of ICT in a country; rather, they gauge the government's commitment to be proactively involved in the evolution of the ICT and broadband sector. Only a government that is open to actively making use of ICT technology can expect to develop and implement broadband services for its constituents.

Particularly with respect to rural broadband, where infrastructure CAPEX costs may impose severe challenges, this proactive involvement is essential to the successful implementation of broadband infrastructure. Consequently,

**FIGURE 4.2** The “Other” Web: The Consumer and Other Broadband Stakeholders



Source: ITSO.

identifying the stakeholders, combined with an objective assessment and commitment to improve digital maturity, needs to be followed by the development of policies and a set of regulations aimed at improving services to end-users.

Regulatory provisions can either hinder or facilitate the rollout of new broadband services and their adoption by end-users. One example of supportive regulatory provisions is granting a new service provider the right and the ability to access and use existing infrastructure owned or under the control of an incumbent operator. Other supportive regulations guarantee a level playing field. A report issued by the U.S. government recently echoed the importance of competition and the need for policies that support such competition. The report states:

While the United States has an extensive network “backbone” of middle-mile connections (long, intra- or interstate physical fiber or cable network connections) with the capacity to offer high-speed Internet to a large majority of Americans, many consumers lack access to the critical “last mile”...especially in rural areas.... Without strong competition, providers can (and do) raise prices, delay investments, and provide sub-par quality of service. When faced with limited or nonexistent alternatives, consumers lack negotiating power and are forced to rely on whatever options are available (Executive Office of the President, 2015).

To conclude, it is essential to create a favorable regulatory environment for the provision of broadband, while considering the interests of all stakeholders. It is especially important to evaluate the political environment in which this policy is formulated.

## **Making Rural Broadband Economically Viable**

Notwithstanding the government’s best intentions to formulate policy that would ensure the widest

possible broadband access, any broadband project must be economically viable and sustainable. For most rural customers, CAPEX, the cost of ongoing operations, low subscriber numbers, and low incomes are typical. In this context, governments have used a variety of strategies to make rural broadband attractive to private venture service providers, including:

- Tax incentives
- Direct government funding for pilot projects
- CAPEX subsidies for equipment procurement
- Public-private partnerships for free Internet access in public areas

The challenge is to ensure that financing is effective and ultimately delivers the desired results, both in terms of output (i.e., the number of customer terminals installed and used), and outcome (i.e., that they perform as intended).

The following measures can help to achieve the desired results:

- Increase transparency through the explicit targeting of subsidies.
- Increase accountability by shifting performance risk to service providers.
- Ensure participation of private sector capital and expertise.
- Encourage innovation and efficiency (World Bank, 2010).

Lessons learned from other infrastructure programs in rural areas are instructive in this context. For example, a study of Nicaragua’s Off-grid Rural Electrification Project suggests that the following are important factors in the success of a project:

- Involve users and communities in decision making and service implementation (participation creates ownership).
- Integrate off-grid policy with the telecommunications sector (regulations, level playing field).
- Avoid driving existing service providers out of the market.

- Design targeted and efficient “smart subsidies” in a transparent way, secure funding, and define an exit strategy.
- Adapt public-private partnership delivery models to local needs and conditions.
- Ensure that users pay a substantial part of lifecycle costs (payment creates ownership) (Barnes and Halpern, 2001; Martinot and McDoom, 2000; Martinot, Cabraal, and Mathur, 2000; Reiche, Covarrubias, and Martinot 2000).

Another example comes from Canada’s Yukon Territory, which has a low population density and is isolated from larger urban centers. The Rural Electrification and Telecommunication Program provides remote end-users with electrical, telephone, and broadband services brought to their homes. The projects eligible under this program include single-site connections, group installations, and alternative energy systems for private use. The program gives property owners the freedom to decide which projects to undertake and how to manage and finance them. The program has a 100-percent cost-recoverable financing regime over a period of 15 years. Owners potentially benefiting from a project are required to make a fair and equitable contribution to the total project costs (Yukon Government, 2015).

### Universal Service Funds

In financing national broadband plans, it is important to consider universal service funds (USFs). A USF is a system of telecommunications subsidies and fees that are managed by a country’s NRA or by specific agencies responsible for this management. They can be an integral source of funding for universal access and universal service strategies. USFs can support universal access initiatives such as rural broadband provision and internet access in schools (FCC, 2015).

An ITU study (Dorward, 2013), presented at the Thirteenth Global Symposium for Regulators, listed the following sources of funds for USFs:

- Separate levy on operators’ annual revenues
- Portion on international call revenues

- Apportionment/allocation of regulatory fees
- Contribution from international agencies
- Proceeds from spectrum auctions
- Direct government budget allocations

In Brazil, for example, 1 percent of all telecommunications revenues from telephone, data, TV, and other services, finance the country’s USF (Interview with Luiz F.T. Perrone, Oi S.A., Rio de Janeiro, June 20, 2015).

Sometimes these funds are not used efficiently for facilitating broadband funding. For example, eight of the 16 funds studied in the LAC region permitted broadband funding, while three were inactive, and another three had low activity. Unfortunately, this is also the case in Brazil, where the USF was established at a time when broadband was not widely used and where the fund’s purpose has not yet been redefined to include broadband services. This is a global pattern; the ITU concluded that many USFs around the world do not fully serve their intended purpose (*ITU News*, 2015).

Although USFs could be a premier funding source for rural broadband, lessons from experience should be considered. One is the need to include broadband in USF objectives. These lessons lead to the following key elements for the establishment and governance of USFs:

Purpose	It must have a clearly defined purpose.
Flexibility	Its mission must be adjustable to changing service demands.
Transparency	There must be transparent governance.
Independence	Its management must be independent from interference by third parties.
Inclusiveness	It must include all stakeholders in its design.
Focus	It must consider the requirements of anchor institutions (schools, libraries, hospitals, etc.)

With respect to the policy and regulatory involvement in the selection of rural broadband technology, two basic principles have been used:

- The regulator is indifferent to the technology employed. Service providers decide what technology (cable, satellite, or microwave) is to be used (Example of Brazil).
- The regulatory body prescribes a technology (e.g., Canada, where the use of satellite broadband is considered a priori the only viable alternative for the country's remote territories).

However, the realities of geography, demographics, and cost, rather than policy and regulation, will ultimately dictate the choice of technology. Consequently, in Brazil, where no specific technology was mandated, satellite broadband became the technology of choice in rural areas.

Finally, an important policy consideration is the stake that local businesses hold in broadband access. In the current economy, many small and medium-sized enterprises (SMEs) need access to broadband to grow their services and sell their products. Access to the Internet can promote innovation and enable local businesses to sell their goods beyond traditional geographical areas and purchase resources from distant suppliers. Rural and remote SMEs have a stake in broadband access, so they should be included in policy and regulatory formulation.

Many factors drive broadband adaptation by local businesses and SMEs, including affordability, relevance, and availability of local applications and content. There are different approaches and business models on how to encourage rural broadband adoption in developing countries. Here are some examples:

- In Brazil, ViaSat Brasil will use EUTELSAT 3B to supplement its existing coverage of rural areas for consumer and SME markets. It will expand its services to enterprise markets and address the increasing demand for Internet connectivity from high-tech companies operating in rural areas beyond the reach of terrestrial broadband infrastructure (Eutelsat, 2014).
- In Colombia (Vive Digital) it was found that, for small businesses, the main barrier to adopting the Internet is the lack of perceived need and

the lack of local Internet applications that can support their business (Fung, 2014).

### *The Concept of a Broadband Ombudsman*

Participation of the local community in demonstrating the value of broadband access and identifying useful local applications and content is a critical project success factor. Local involvement needs to start early in the project preparation stage to quickly demonstrate success and needs to be organized. In other words, the community should play a role, for example, through representation by an ombudsman familiar with the local economic needs, culture, and politics.

The concept of a broadband ombudsman derives from the fact that many end-users lack basic knowledge of digital technologies. Since they are not educated interlocutors with ISPs, they require assistance by a consumer advocacy institution. Depending on the size of a given broadband project, the ombudsman can be a single person or a small office of consumer representatives. The following selection criteria are relevant when appointing an ombudsman:

- Familiarity with local customs, culture, and socio-economics
- Recognition and trust by consumers and other stakeholders
- Understanding of broadband business and technology
- Early involvement in the project
- Proper definition of responsibilities and authority
- Independence from commercial interests
- Access to high-level decision makers in policy, regulation, and industry

The ombudsman would, throughout planning, implementation, and operation of a broadband project, represent the end-users' interests and serve as a point of contact in all cases of consumer complaints that cannot be resolved between the end-user and the ISP.



## Technology Alternatives for the End-User

### *Broadband via Satellite*

With a few exceptions, traditional broadband system solutions tend to comprise the following technical components for end-to-end delivery of broadband access:

- Generic components that apply to all satellite telecommunications systems, such as satellite transmission capacity, antennas, and hub facilities with interconnection to the broadband backbone, which the ISP is responsible for installing on the end-user's premises
- Broadband-specific components

For the latter category, there is a set of satellite broadband vendors and manufacturers focused on providing satellite broadband systems. They include Hughes, ViaSat, Gilat, iDirect, Advantech, and others. The satellite broadband vendors provide the equipment necessary to convert broadband bandwidth (presented to the system as Mbps) into modulated signals that travel across the satellite link. Equipment includes components deployed at the central "hub" sites and at the remote very small aperture antenna (VSAT) sites. While remote-site dishes may be generic, satellite broadband equipment vendors increasingly offer pre-integrated and tested remote site terminals.

Satellite user terminals are required to receive satellite broadband services. They include a satellite dish, cabling, and outdoor and indoor equipment (see Figure 4.3). The indoor equipment looks like a cable modem and is similar in size. It provides the end-user with the Ethernet port to connect to the computer or Wi-Fi access point. The terminal also connects to small cells or even macro cells in hybrid, multi-user satellite-cellular deployments.

Terminal costs are based on frequency band and network characteristics. Typically, they cost between US\$300 and US\$800 for large consumer broadband deployments, and between US\$600 and US\$2,000 for enterprise-class terminals.

## Broadband via Wireless Backhaul over Satellite

There are instances where it becomes more efficient to address the digital gap through hybrid delivery of broadband to end-users. This is particularly due to the proliferation of smartphones, which offer greatly expanded functionality compared to basic mobile telephone sets. An increasingly common and often cooperative approach is using satellite links to connect remote cell towers to the core network. This approach is called "satellite backhaul," because satellites are used as a middle-mile (i.e., backhaul) connection (Figure 4.4).

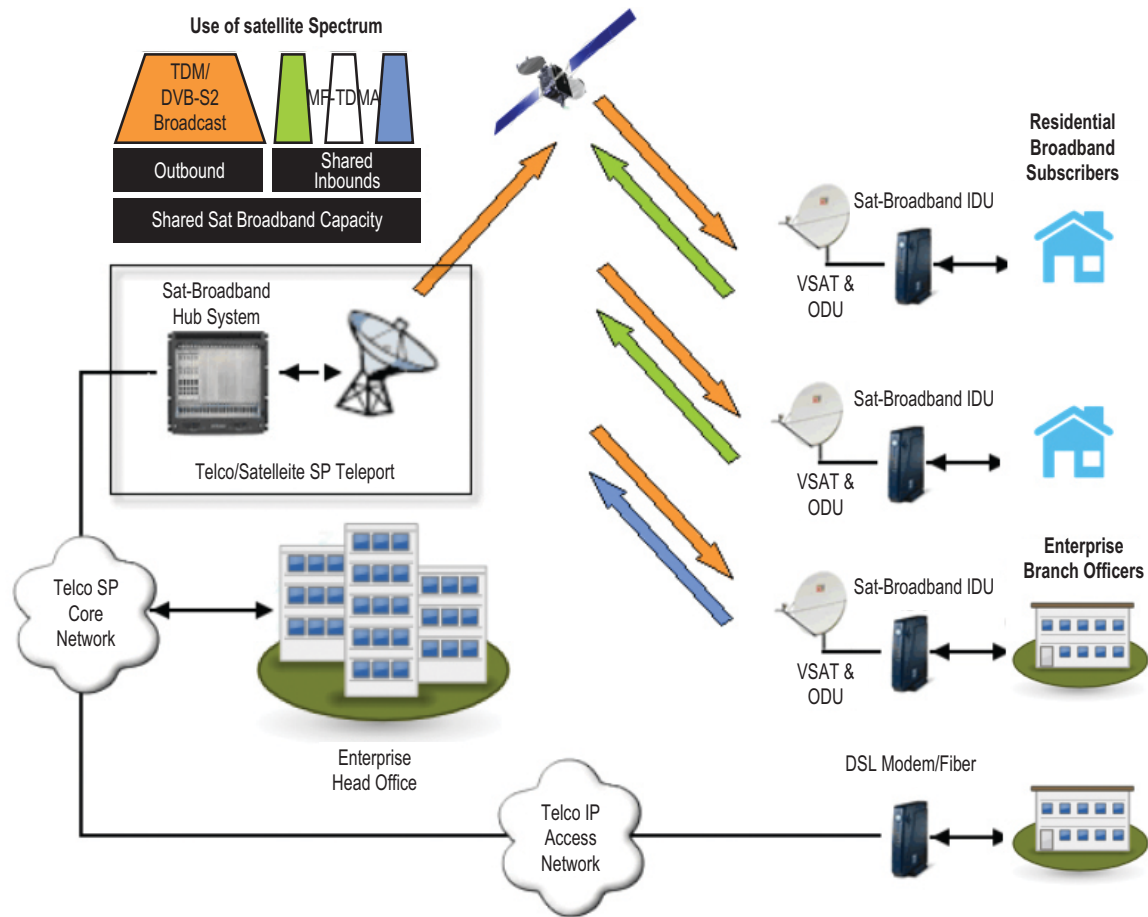
Broadband access arrives wirelessly to end-users with several technologies used as last-mile wireless. Wi-Fi and 3G are the most common. With the introduction of low-cost, small-cell technology, hybrid satellite wireless delivery will become increasingly effective for bridging the digital gap in locations with low population densities.

2G technology, which has very limited capability for data access, largely dominates cellular backhaul over satellite in Latin America. Pressed by the regulators, mobile network operators have started deploying 3G and LTE sites with satellite backhaul, but the traffic-revenue divergence driven by an increasingly data-driven mobile environment has brought economic challenges for 3G and LTE over satellite. Operators must often choose between deploying 3G/LTE remote sites at a loss and paying fines to the regulators for not meeting the deployment timeline. Introducing more HTS platforms will ease these economic tensions and better allow mobile network operators to close a positive business case for 3G and LTE in remote or hard-to-reach areas. Developments in cellular backhaul optimization and acceleration technology (bandwidth optimizers) will facilitate this decision.

## The Role of the Internet Service Provider

The Internet service provider (ISP) is a crucial player in the provision of end-user broadband service: it deals directly with the end-user on a daily

**FIGURE 4.3 Residential and Enterprise Satellite Broadband Diagram**



Source: ITSO.

basis. The formal arrangement between the ISP and the consumer, known as a service-level agreement (SLA), is the key instrument that defines the service to be provided.

Since end-users are not in a position to negotiate the terms of this agreement, regulators play an important role in defining SLA provisions and monitoring ISP performance after the commencement of service. Moreover, regulators need to implement simple and transparent procedures to process end-user complaints.

### Service Level Agreement

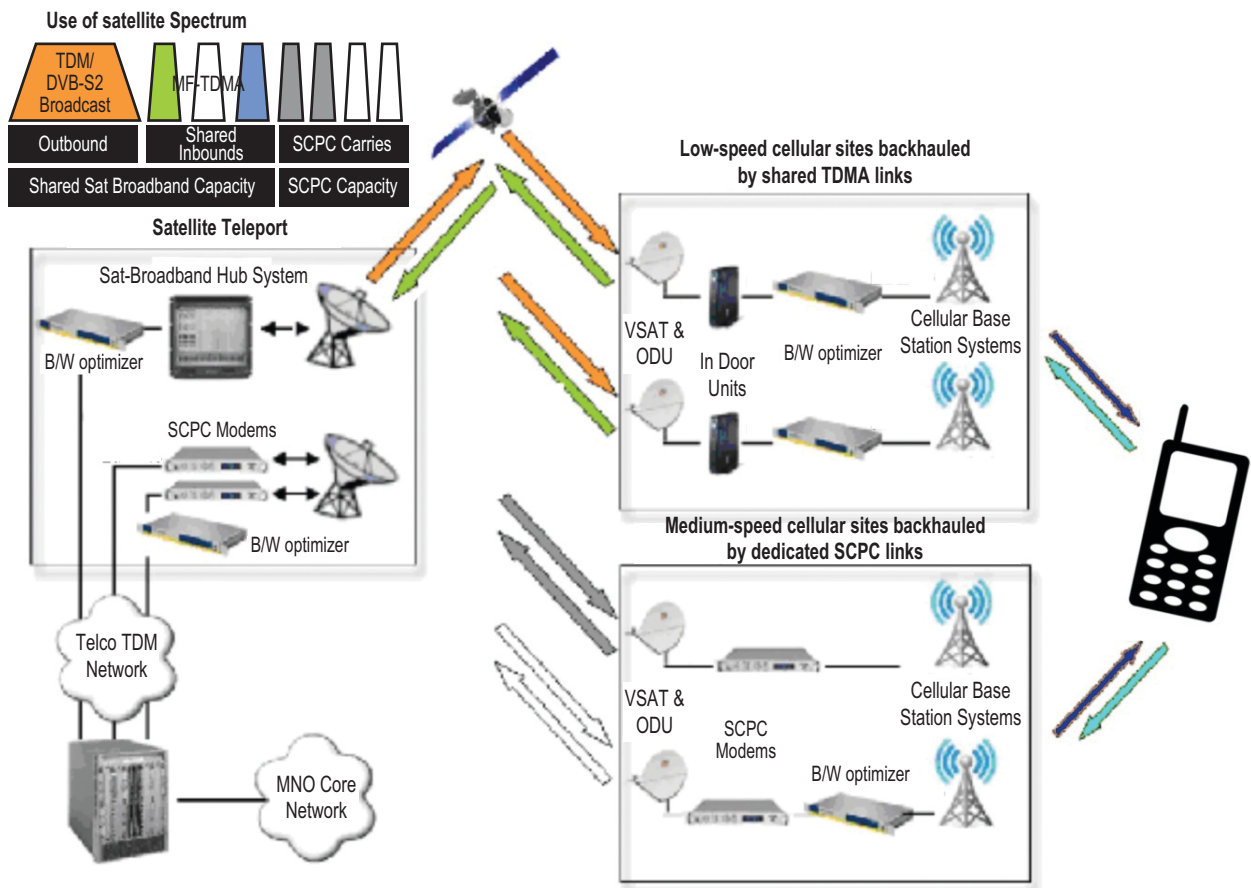
The SLA details the nature, scope, and quality of the services that the ISP will provide. It also defines the

responsibilities of the ISP and the end-users. An SLA codifies the success criteria that will be used to audit and evaluate service delivery and usability. A broadband SLA typically defines service deliverables, service delivery time, and key performance indicators, or metrics, to measure service quality and performance. Among others, an SLA should do the following:

- Identify the end-user groups and the service needed for specific key applications
- Define the target service levels to include service performance, service availability, maintainability, reliability, and quality
- Use target service levels to formulate a brief and effective master SLA from the end-user perspective, and outline responsibilities of



**FIGURE 4.4 Wireless Backhaul via Satellite**



Source: ITSO.

service provider (including technical assistance, service credits and penalties) and end-user (e.g. fair access policy, acceptable use policy)

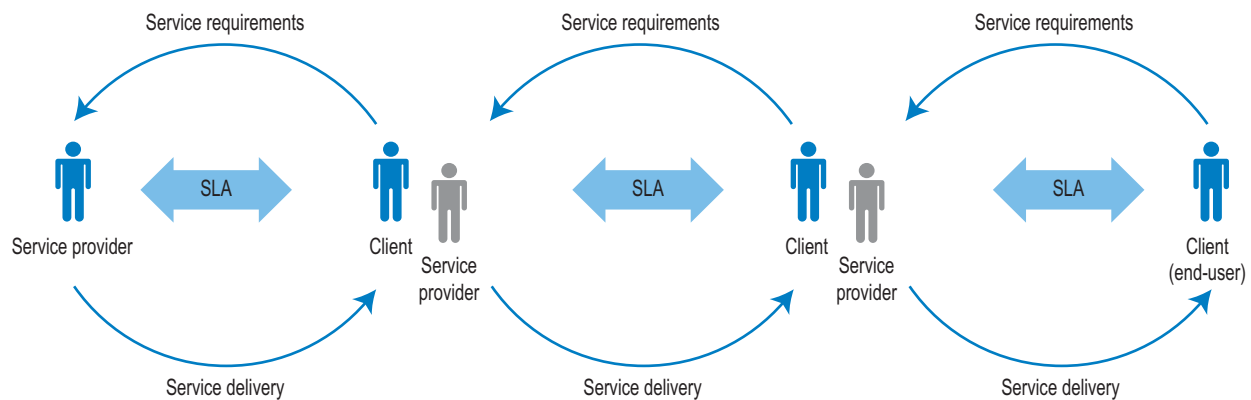
- Use language that can be understood by all stakeholders, which will be used for project communications
- Specify basic end-user requirements and responsibilities
- Ensure that the entities that implement the broadband service define the measurements needed to evaluate the service against the master SLA targets and how the measurement will be carried out
- Agree on a reporting mechanism and ensure that arrangements are in place to review the

SLA periodically together with service performance measurements, and allow for adjustments and refinements of the SLA based on end-user experience

- Ensure a minimum level of acceptable service performance
- Manage expectations from the end-user and the business perspectives

Figure 4.5 represents a generic three-tier (multiple service providers) SLA model. Applied to satellite-based Internet broadband service, the figure would read from left to right as Satellite Service Provider, Network Operator (wholesaler), Local ISP (retailer). Some satellite operators (e.g., Hughes, ViaSat) could also provide the service directly to

**FIGURE 4.5 Example of a Three-tier SLA Model**



Source: ITSO.

the end-user, without an intermediary, through their technology that brings broadband directly to the end-user's premises.

Accurately measuring broadband performance from an end-user perspective is complex and typically involves measurements of the following key parametric indicators:

- Maximum achievable download and upload speed (in Mbps) during average and during peak utilization periods.
- Round-trip time or latency (in milliseconds), defined as the time it takes for the traffic to reach a particular destination and return. This is important for 2-way, interactive applications such as voice-over IP (VoIP), video conferencing, or online games.
- Packet loss (in percentage terms), defined as the percentage of packets that do not reach the destination. High packet loss can impair applications such as video streaming, VoIP, and video conferencing.
- Jitter (in milliseconds), which is the variation of end-to-end delay from one packet to the next, within the same connection/flow. High jitter may impair real-time applications, such as VoIP and video conferencing.
- Service availability, which defines the time (in percentage terms) during which the broadband service is available for the end-user. Service

availability may be different for different applications. For example, a fair use policy could restrict the use of certain bandwidth-intensive applications during peak hours to ensure that basic applications (e.g., email, Web browsing) can still be used and are not impaired by less essential applications (e.g., gaming, video streaming).

A number of other factors that should be included in a successful SLA include ways of monitoring quality, billing, and customer care. Below is a brief overview of these issues.

### *Throughput Auditing*

The SLA should define which technical parameters the ISP needs to measure, monitor, and audit regularly to verify fulfillment of the desired overall service objectives. Moreover, the ISP should be required to provide monitoring data to the regulatory authority.

Having the appropriate network throughput and performance measurement points is also critical for network capacity planning, assessment of application performance, network-performance trouble isolation and resolution, and active network fault monitoring.

### *Interfaces for Billing and Customer Care*

Application program interfaces (APIs) are key to outlining the initial needs and requirements of end-users

and service providers, such as billing and customer care. APIs are the digital glue “which binds products and applications together and provides the mechanism to access business assets” (Woods, 2011: 2).

### ***Audit of Real Service Quality and Throughput, End-User Perception***

Measuring and assessing network performance and end-user experience is challenging, because it depends on subjective as well as objective experiences. Studies find no single method for measuring speed that is appropriate in all application contexts (Bauer, Clark, and Lehr, 2010). While an end-user could take one of the many readily available speed tests on websites (e.g., Speakeasy) to measure download and upload speed, such a measurement would be subjective because it depends on many factors, including the test used and the time of day.

Generally, a broadband customer primarily using web browsing and email without large file attachments will create an asymmetrical data stream where the downstream (from the Internet to the customer) is substantially larger than the upstream. However, for a user site hosting a web page (e.g., a local business), or running frequent large file transfers, the upstream data rate will become important.

The last issue affecting perceived broadband performance is network sizing versus the actual traffic profile. Typically, network plans are based on mutually agreed upon traffic assumptions and estimates. Such estimates are inherently inaccurate and difficult to make. Only as long as the actual traffic pattern is within the assumptions used for network sizing, an end-user can expect to experience the stated data rates most of the time. If the actual traffic pattern differs from the assumptions, it will very likely adversely affect end-user experience, such as, for example, when there is more traffic than was assumed.

### ***Management of System Resources and Utilization***

The ISP is responsible for management and monitoring of system resources (e.g., satellite bandwidth)

and utilization of the service. They typically require some coordination among several service providers involved. It is essential that monitoring and measurement of system utilization match the requirements needed to evaluate service delivery in accordance with the SLA in place between the ISP and the end-user. Monitoring practices should automatically trigger actions for maintenance (including dispatch of maintenance specialists to a remote site) in accordance with the SLA.

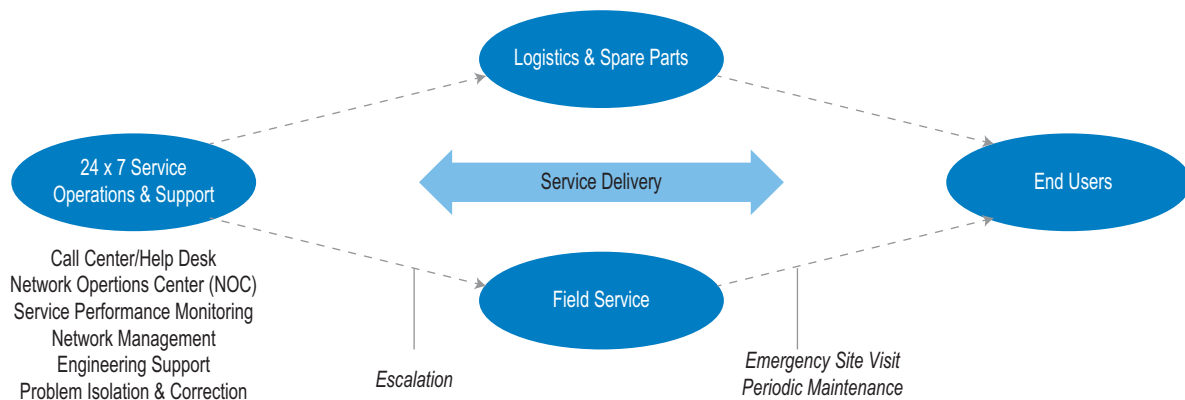
The challenge is to have the technical support and maintenance organization in place and have escalation procedures established to enable the responsible party to act on a maintenance issue. As a general strategy, the ISP should consider the following elements:

- Use of an intelligent, centralized network monitoring system that can proactively trace issues to the subsystem/component level, and, in accordance with the established SLA, raise a maintenance alarm and trigger maintenance action
- Periodic (e.g., quarterly) review of system resources and utilization
- Monitoring of service usage pattern (i.e., applications, intensity of use) and a mechanism in place to add capacity based on increased service demand
- A way to ensure network throughput optimization and performance, and the possibility of deploying technology that can enhance service experience from the end-user perspective. For example, the use of a caching server located at the base transmitter station of a cellular network will minimize download for all frequently accessed web contents, and at the same time reduce cost for satellite capacity by reducing traffic over the satellite.

### ***Customer Service Organization and Equipment Distribution Channel***

Figure 4.6 illustrates how end-user needs, customer service organizations, operational support,

**FIGURE 4.6 Operational Support Arrangements and End-user Needs**



Source: ITSO.

field service, logistics, and equipment distribution channels are closely inter-related aspects and directly affect service reliability and equipment maintainability.

Planning service and equipment maintenance should begin early in the acquisition phase of a broadband project with the development of a maintenance and technical support concept covering all aspects required to restore and to maintain service. Ultimately, a master SLA should specify basic end-user requirements and the responsibilities of each party in the project preparation stage and before equipment acquisition. The SLA will later become part of the service contract.

It is important to distinguish between equipment (durable goods), spare parts, and consumables (non-durable goods), which are used up as part of normal service operation. Generally, the end-user is responsible for consumable goods (e.g., printer toner/ink cartridges, paper, and data backup media), which are therefore excluded from product warranty policies. However, arrangements to resupply should be in place in all cases where the end-user is part of a public service. Moreover, in very rural settings, where the supply of consumables may be very difficult to assure, a supply strategy needs to be developed and implemented to guarantee sustained operation.

All major providers of broadband equipment have local distribution channels and partners in

Latin America to cover logistics, distribution, and installation and maintenance services. Local spare equipment depots, possibly co-located with a service support center, are highly desirable, as they ensure that spare equipment and maintenance personnel can be on-site within the specified response time following a field service request. There are also alternate equipment distribution channels, including independent logistics companies, such as Aerodoc, which have import licenses through agents or partners, and equipment storage facilities in many Latin American countries to ship and store satellite-telecommunications equipment.

Specific end-user and system requirements need to be formulated during the project preparation stage prior to project appraisal and funding approval. This process should consider the followings aspects:

- High import duties and taxes imposed by some countries on imported telecommunications equipment
- Locations of network operations facilities, end-user help desks, and other support and administrative functions

### Consumer Premises Issues

From an end-user perspective, it is vital that the equipment is available, paid for, and operated for

efficient broadband service. In light of the specific circumstances of rural broadband service, the following sub-section discusses the challenges and success factors of the rural end-user environment and the technology typically operated on the end-user's premises, and throughout the system, in support of service to the end-user.

### ***Challenges and Success Factors of the Rural End-User Environment***

Although there is no generally accepted definition of a rural environment and population, there is agreement that rural areas have one or more of the following characteristics: low population density; poor or non-existent infrastructure (electrical grid, telecommunications); remote access often hampered by natural obstacles (mountains, rivers); and use of natural resources as the primary source of income (World Bank, 2014). As discussed in Chapter 2 of this study, distance, type of settlement, and unavailability of broadband access divide rural areas into the following four scenarios for the deployment of satellite broadband access technologies:

- Rural villages and small towns with commercial and administrative facilities, with existing electric power but without existing broadband connections
- Small rural clusters with limited commercial and administrative structure, with limited electric power available, and without existing broadband connection
- Single rural settlements, located more than two hours from commercial, administrative hubs with no, or limited, electric power available and with existing broadband connections
- Remote farms and small communities that are not part of a larger settlement and typically have no access to electric power

In each scenario, there are challenges for the initial deployment (rollout) and the subsequent utilization phase of satellite-based broadband

technologies. For example, a supporting energy source to enable broadband access may be lacking. In this case, renewable energy technology solutions, such as solar, micro-hydro power, and wind, must be available and combined as needed to address this challenge. However, their deployment will have to be closely coordinated with the deployment of satellite broadband technology.

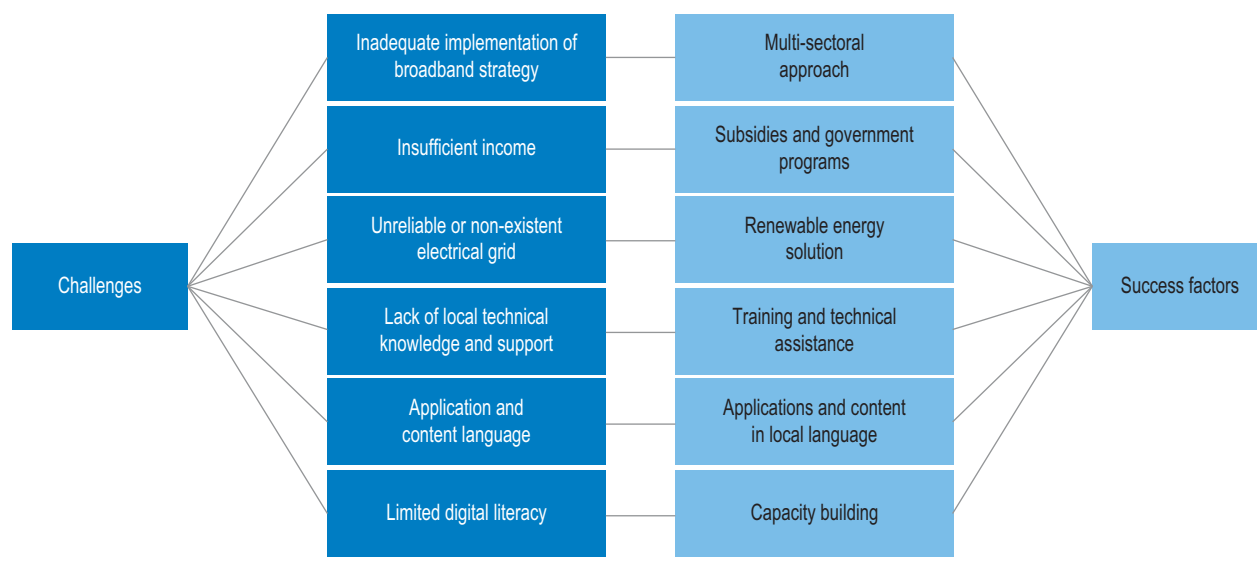
In addition, local technical knowledge and technical support (e.g., to resolve performance issues, arrangements to repair and/or replace non-working equipment, maintain hardware and software, resolve security issues, etc.) may be unavailable. Training the end-user to provide adequate and consistent technical assistance is critical for technical sustainability and adoption of broadband use.

It is also important to provide applications and content in local languages. Applications that have immediate practical value to end-users will be an incentive for the productive use of broadband. These applications could include access to local weather forecasts and the means to obtain market prices for agricultural products that a farmer wants to sell. Of special importance are applications related to health care and education, such as online consultations with the nearest hospital and distance-learning programs with regional and national educational institutions. They are a testimony to the benefits of broadband.

There is also the possibility that end-users will not be able to afford broadband access and services at the price required for a commercial service provider to make a profit. It is therefore important to consider subsidies and other government programs that would make these services more accessible.

As shown in Figure 4.7, governments must overcome a number of challenges if rural broadband is to be successful. Even when the appropriate telecommunications infrastructure has been set up, there is still the obstacle of building the end-users' capacity to use these services. Digital literacy is a skill set that allows a user to access the Internet, navigate websites, and create information through

**FIGURE 4.7 Challenges and Success Factors of Rural Broadband Deployment**



Source: ITSO.

digital technology. Lack of knowledge about how to use the Internet is often a greater obstacle to digital inclusion than cost or coverage. In that case, it is imperative to combine rural broadband programs with capacity building.

In this context, several studies suggest an overall approach that cuts across multiple sectors, such as energy, education, and health care, and takes ongoing or planned development activities in these sectors into account. It recommends close coordination between government entities at all levels, technology providers, private entities, local rural organizations, and funding organizations.<sup>13</sup> Successful implementation of such an approach requires the adoption of project management and systems engineering methodologies, combined with criteria for a successful outcome and guidelines for technology selection and implementation.

The implementation of a rural broadband program occurs mostly through a top-down approach. In order to implement rural broadband successfully, it is crucial to begin with a clear vision and implementation strategy, which will be translated into implementation guidelines and success criteria. Then, it is important to develop

implementation roadmaps and plans. After that, it is imperative to explore the local site conditions and end-user needs. Integral to all of this is dialogue between the private and public sectors as well as the local communities and other stakeholders during implementation. Figure 4.8 highlights the main success factors for rural broadband implementation.

### ***Satellite Broadband Equipment and Supporting Network Installations***

The following equipment is required at the end-user's premises, as well as ISP equipment to support a larger broadband network.

- At the end-user's premises:
  - VSAT Antenna
  - User terminal (VSAT) or out-door unit (ODU) equipment
  - Customer provided equipment (CPE)

<sup>13</sup> See <https://www.ligtt.org/50-breakthroughs>. See also <http://unpan1.un.org/intradoc/groups/public/documents/un-dpdm/unpan049753.pdf>.



**FIGURE 4.8 Rural Broadband Implementation Success Factors**



Source: ITSO.

- The network has:
  - VSAT gateway earth station
  - Call center (customer help desk)
  - Network operations center (NOC)

The most prominent subsystem at the remote site is the very small aperture (VSAT) antenna. VSAT's size typically ranges from below 1 meter to a few meters in diameter.

The outdoor unit (ODU) consists of a small VSAT (antenna) and radio frequency terminal (RFT) equipment. Countries must select ODU components in accordance with the satellite frequency band used for service (e.g., Ku-band or Ka-band) (Figure 4.10).

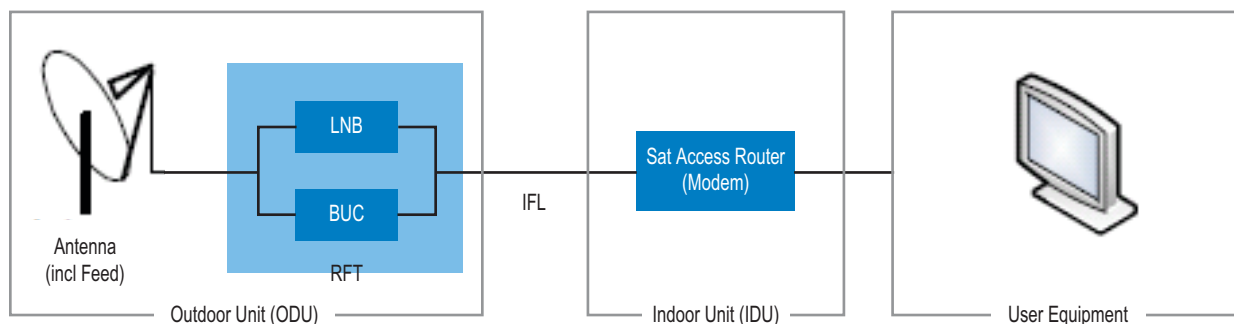
The satellite dish, typically parabolic in shape, can be mounted at any location where the antenna has a clear, unobstructed view or line of sight to or from the satellite. The actual dish size depends on many factors, such as satellite frequency band, geographic location with regard to the coverage area of the satellite beam, satellite signal strength, desired maximum reception and transmission data rates, and intended use. The higher the satellite frequency band, the smaller the VSAT dish size can be, and vice versa. A bigger dish can provide better reception in remote areas and can support much higher data rates.

A block up converter (BUC) is used for the uplink of satellite signals to convert a block (band) of lower frequencies to a higher frequency. A low-noise block converter (LNB) is used to convert the radio signal received by the antenna to a lower frequency, which can be processed by the indoor satellite modem.

As shown in Figure 4.9, BUC and LNB are normally mounted at the focal point (feed horn) of the antenna, which receives and transmits data from and to the satellite.

The interfacility link (IFL) connects the ODU equipment with the indoor unit (IDU) equipment.

**FIGURE 4.9 Generic VSAT Block Diagram**



Source: ITSO.



**FIGURE 4.10 Outdoor Unit**



Source: ViaSat, 2015.

The IFL typically consists of low loss coaxial cable with a maximum length of about 100m.

The IDU equipment, as the name implies, is located indoors. It typically consists of a single satellite Internet modem/router, connected to the customer-provided equipment (CPE). The IDU codes and decodes satellite data signals to be used with a computer or other end-user equipment. IDU components are independent of the satellite frequency band used for service.

Finally, the end-user will want to operate the CPE, including a computer, desktop, laptop, and smart phone, with various accessories, such as printers, wireless routers, and others. These components ultimately represent the man-machine interface between the end-user and the global broadband network.

In addition to the abovementioned equipment used at the end-user premises, it is important to consider the ISP equipment needed for network installation. The network side opposite to the community of end-users requires the satellite links to be connected to the broadband backbone network. A teleport or gateway earth station, also known as a “hub,” links one or more satellite networks to ground-based communications equipment.

The equipment comprises an antenna, radio frequency (RF) components, satellite base band equipment, network management systems, network routing and security elements, and other application-specific components. A teleport typically has common infrastructure elements to provide equipment power as well as environmentally controlled secure facilities to house communications equipment.

Due to the hub’s critical, single point of failure importance, it has multiple levels of built-in redundancy for all the elements in the communications path, starting with the antenna and ending with the equipment connecting to the fiber backbone. The same approach extends to common infrastructure such as electric power (provided in a hybrid combination of primary electrical grid, backup battery, and a diesel generator). If the primary power grid fails, batteries would provide electric power until the diesel generator starts and replaces the primary electric power supply source.

From a network operator point of view, combining gateways with existing, larger satellite teleports is advantageous, since it leverages existing common infrastructure (lower implementation cost) and minimizes the time taken to install the hub equipment, and subsequently to provide service. Experienced staff is generally available to operate satellite earth stations. Presently, more than 190 operational satellite teleports in South America could be used for broadband (CIA, 2015).

Other considerations include regulatory aspects and flexibility with regard to future service expansion. Given the right satellite coverage, a gateway (hub) could be located anywhere, even beyond national boundaries. However, such an approach would have the disadvantage that any traffic to Internet servers located in the country would involve transit through another country, thereby increasing propagation delays and possibly cost. In addition, the regulatory authorities of many countries dictate that any Internet service must originate within the country’s national borders. Therefore, a satellite gateway would need to be located within the national boundaries and

connect to the national communications backbone. Service providers and satellite operators must also ensure that the satellite they use for service is licensed and has landing rights in the country it services.

In a typical satellite broadband network, in addition to the gateway earth station, a call center or help desk provides a single point of contact for technical assistance to the end-user, or to a service provider connected to the satellite broadband network, while reselling the service to end-users. The SLA defines the roles and responsibilities of the call center. The call center is often part of a multi-tiered escalation approach in a layered service constellation.

Finally, a network operations center (NOC) may be located within the satellite earth station gateway and typically has full-time staff. The NOC is the escalation point from the call center point of view. The primary function of a NOC is the management of satellite network resources and the services provided to the user. These responsibilities include the following:

- Service activation/de-activation, service changes
- Monitoring of network performance
- Troubleshoot and correct network errors
- Address problems escalated from customer call center (help desk)

The tools available to NOC staff include a combination of network management system (NMS), operations support system (OSS), and business support system (BSS) components and related software. Call center and NOC may have collaborative but different roles.

## Ancillary Success Factors

In addition to the requirements for a functioning satellite broadband system, a number of ancillary aspects should be considered to make broadband services accessible and accepted. Although they are beyond the scope of the consumer and part of the ISP and network operator's responsibilities,

they should be critical success factors. These considerations include installation and maintenance issues, as well as both physical and cyber security and safety. In addition, electrical infrastructure and sustainable power options will need to be explored to complete the approach to the provision of end-user broadband services.

## Installation and Line-up Strategies

It is essential to have clear installation and line-up strategies. Planning, preparation, and conducting installation and line-up activities at the user's premises plays a major role in optimizing service reliability and service performance and in minimizing maintenance costs during the operational stage.

To have an effective VSAT installation and line-up strategy, it is crucial to:

- Collect, analyze, and share the following among all key project stakeholders:
  - Relevant local site information (geographic location relative to satellite beam coverage, topography, aerial images, distance to nearest regional administrative center, any existing local electrical infrastructure, available spectrum options).
  - Local community data (demographics, population density, economic activities, income).
- Conduct a site survey prior to installation to select a suitable physical location for both antenna and, as needed, alternate electrical energy source (e.g. solar panels), and to identify any pre-requisite activities (e.g. construction of an antenna pad).
- Conduct user site installation in accordance with established technical support and maintenance processes and procedures (e.g., dispatch of field maintenance personnel to repair a site).
- Ensure that installation, line-up, and service activation can be performed without the need for real-time voice coordination between the VSAT installation team and personnel at the NOC.

- Ensure that electronic records of installation parameters are archived as a reference to assist with problem resolution during service operations (e.g., receive and transmit signal levels, spectrum, and digital pictures of site installation).
- Use certified installation personnel to ensure best performance and mitigate or avoid interference during operation through misaligned equipment.
- Conduct basic end-to-end service validation as a final step of site installation.
- Provide basic operational safety instructions and product use instructions to end-users.

Execution of the installation and line-up strategy will require close coordination among key stakeholders, with local community involvement. The degree of achievable service reliability and robustness depends on local site conditions, the installation and line-up approach, and product choice.

In the past, a limited number of large earth stations dominated satellite telecommunications and whole crews of trained technicians were available. Today, the challenge of commissioning a large num-

ber of small user terminals forces an approach where single technicians have to line up a substantial number of terminals in a short time. To accomplish this task, several tools and applications are available that allow a single person to install and line up user broadband equipment without the need for real-time interaction with the NOC and that only require the installer to bring a laptop or smart phone to the remote site. All satellite broadband technology providers have these tools and have them integrated in their product to some degree.

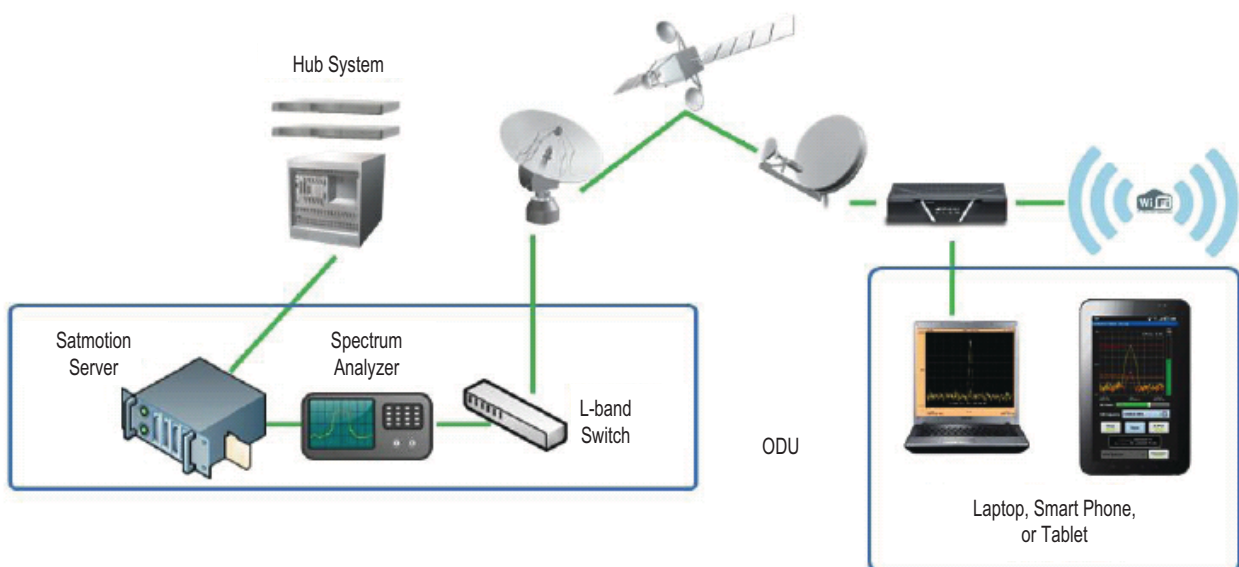
Figure 4.11 shows one solution for remote site commissioning. The solution is easy to use, supports antenna pointing, polarization alignment, and signal level adjustment. It does not involve real-time coordination with NOC personnel.

### *Maintenance, Repair and Reliability Issues*

In addition to having clear installation and line-up strategies, it is crucial to consider maintenance, repair, and reliability.

In general, the following factors drive service maintainability: technical and maintenance support arrangements, end-user knowledge, geographic

**FIGURE 4.11** Example – iDirect Remote Commissioning System Configuration



Source: iDirect, 2015.

location of the access point (i.e., how easy is it to reach a remote site, and within what time), and architecture of the deployed broadband access network (e.g., redundancy arrangements).

It is essential that all stakeholders responsible for implementation of rural broadband service establish a common definition of service reliability and maintainability targets and codify these requirements as part of a master SLA. Regulatory authorities will have to act on behalf the end-user. Equipment maintainability depends on availability and access to maintenance and repair facilities, spare parts, local support staff, and quick turn-around time. To mitigate the risk that the deployed broadband technology cannot be adequately maintained in remote areas, the following overall strategy is proposed:

- Leverage the customer service organization and equipment distribution channels of the broadband service providers and product suppliers.
- Keep equipment/device configurations as simple as possible and, when in doubt, choose reliability and robustness over features.
- Allow all deployed systems to be monitored and controlled from a central facility (e.g., call center, NOC), and as per the SLA, automatically trigger maintenance actions, including dispatch of field maintenance personnel to a remote site. This concept assumes monitoring across different systems, which are normally the responsibility of different parties.
- Arrange for regular site visits to inspect:
  - Site status/performance
  - Upgrades/carry out maintenance repairs
  - Performance checks
- Train end-users on how to use equipment safely (avoid service breakdown).
- Identify local individuals to provide a first level of maintenance support to end-users (potential for creation of new jobs as broadband use expands).
- Identify nearest city or town with telecommunications services (e.g., mobile operators,

DTH service providers) and infrastructure and equipment repair capabilities, and explore the possibility of sharing these facilities or using them as a spare equipment depot.

- Keep a minimum set of spare parts on-site according to the recommendation of the broadband equipment provider.

In the absence of a good site-specific system and equipment reliability, an alternate way of specifying reliability may be appropriate using a combination of maintenance-free operating periods and a maintenance recovery period. The latter is the length of time needed to bring the system back to the state where the maintenance-free operating period can be restarted.<sup>14</sup> The traditional approach defines reliability as the probability that a service can be used as intended for a specified time, and uses mean time between failures (MTBF) as key metrics. Service availability in turn is defined as:

$$A = \text{MTBF} / (\text{MTBF} + \text{MTTR}),$$

where MTTR is the mean time to repair or restore the service.

However, service availability alone is not an adequate measure for service usefulness and quality from an end-user perspective. Using the formula above, availability will remain high even if the failure rate increases as long as the recovery period is short enough to compensate for the increase in the failure rate. It is conceivable that a highly intermittent service (very short interruptions) with automatic recovery could still have a high availability figure, if such a situation could keep many applications working in a useful fashion. Consequently, robust technical support and building local involvement and expertise are critical for the sustained operation of satellite broadband systems in remote settings.

<sup>14</sup> See <http://www.emec.org.uk/guidelines-for-reliability-maintainability-and-survivability-of-marine-energy-conversion-systems/>.

## Electrical Infrastructure

The availability of reliable electric power is the most essential infrastructure prerequisite for successful system implementation and operation.

A 2009 report by the IEA estimated that in rural Latin America, less than 75 percent of the population had access to the electrical grid.<sup>15</sup> Therefore, provision of broadband Internet access in rural areas cannot be separated from providing an affordable and reliable source of electricity. Although the lack of reliable electric power and suitable facilities to install telecommunications equipment can be a challenge, there are other proven and cost-effective solutions available.

Alternative energy sources are the economical solution in remote and rural locations that lack a commercial power supply. In its latest report, the International Renewable Energy Agency (IRENA), an intergovernmental research organization, concluded, “Today’s renewable power generation technologies are increasingly cost-competitive,” and for off-grid and remote locations, “there is now almost always a renewable solution that costs less than diesel-fired electricity.”<sup>16</sup>

## Renewable Energy Solutions for Broadband

The most common renewable energy-based technologies include solar photovoltaic (PV), wind power, micro hydro, and biomass energy. These technologies have been successfully deployed in many areas around the world, and serve either as primary sources of electricity in areas and locations which have no access to electricity or as complementary electricity sources in grid-connected areas where electricity is not reliable.

Of the abovementioned technologies, solar PV and wind power are best suited for telecom solutions in remote locations for the following reasons:

- Highest location flexibility among all renewable energy solutions, which allows the technology to be installed and used close to where electricity is needed.

- Technologies are already widely deployed and used for telecom installations in rural areas.
- Compared to other technologies, they are easy to install and maintain and they require only basic end-user training.

Several international organizations have active programs for innovative energy technologies for rural communities in some Latin American countries (Argentina, Peru, Ecuador, and others). In addition, the IDB has pilot programs for the Electrification of Isolated Rural Communities using Renewable Energy (IDB, 2013). New programs to provide broadband Internet access to rural areas may want to explore and consider coordinating their efforts with ongoing efforts of rural electrification in the same geographic regions because of potential synergies (e.g., lower combined infrastructure construction cost and reduced construction time).

In conclusion, renewable energy technologies such as solar PV and wind power are well suited for telecom applications in rural and remote areas with non-existing or poorly functioning commercial electric power. These technologies can be operated in hybrid arrangements. Each option is best suited for a specific geographic location. It is crucial to have a good understanding of the local power needs and site condition.

## Safety and Security Considerations

Safety and security aspects are important. Some of the common safety and physical security concerns for broadband infrastructure installations and operations in remote locations include operational safety aspects, physical safety aspects, and cybersecurity threats. Identifying and understanding potential safety concerns and security threats in the project preparation stage is important. These threats are specific to the environment and

<sup>15</sup> See <http://www.worldenergyoutlook.org/>

<sup>16</sup> See <http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=494>.



geographic location where equipment/systems are deployed and operated.

### *Operational Safety Aspects*

From the end-user perspective, the following steps should be integral parts of the project preparation and implementation stages:

- Identify any operational safety requirements or concerns in accordance with applicable national and local regulations (if any).
- Install all VSAT equipment in accordance with service provider and manufacturer recommendations (including electrical grounding of equipment, lightning protection).
- Cover safety aspects in training programs for end-users and maintenance personnel.

### *Physical Security*

Physical security and safety aspects largely depend on local conditions (e.g., security concerns in rural areas with political instability). However, generally, physical security includes equipment protection against willful (e.g., deliberate attacks, theft, equipment tampering, vandalism) or unintended damage (e.g., failures and natural events, such as flooding, storms, and earthquakes). Theft of copper, fuel, telecom equipment, and diesel generators is a particular concern and a widespread problem in many countries. The damage caused by copper theft is often several times the value of the metal stolen.

Security system technologies include door locks, video/audio surveillance, motion detection, and other methods for deterring, delaying, assessing, communicating, and responding to potential security threats and breaches.

The need to implement physical security measures applies to all sites, but what should be done at a particular site is a tradeoff between the actual and perceived security threats, consequences of security breaches, and cost tradeoffs. These cost tradeoffs include, for example, the cost of preventing damage versus the cost of replacing damaged equipment.

End-users are typically assumed to be responsible for physical VSAT site security. For public facilities such as schools and government offices, an integrated security system is advisable because equipment damage typically affects an entire community.

Simple security measures, such as roof installation of solar PV panels, fencing of outdoor VSAT installations, and using lockable facilities that house the equipment, can be taken to discourage unauthorized access and equipment theft. Wireless operators deploy pre-fabricated, lockable equipment shelters of all sizes, as long as electric power is available.

### *Cyber Security*

Cyber attacks and theft of personal and business confidential data are a common threat, and preventing cybercrime is a growing industry. One report estimated the annual cost to the global economy in 2013 to be in the range of US\$300 billion to US\$1 trillion (0.4 percent to 1.4 percent of GDP) (CSIS, 2013).

Due to the severity of the risk and its economic impact, countries must have a cybersecurity strategy, ideally aligned with national regulations, to guide product selection and broadband infrastructure implementation. End-user-specific cyber measures should cover the following:

- Implementation of broadband infrastructure with built-in cybersecurity (e.g., firewalls, antivirus software, password protection of all devices that allow it)
- Provision of cybersecurity training to end-users (e.g., protection against common threats, selection of strong passwords)
- Control of physical access to computer equipment whenever possible
- Creation of end-user accounts with limited administrative privileges to a small number of trusted people
- Periodic security audits of satellite gateways and public broadband access point installations. It is also important to ensure that latest software updates are applied.

## *Training of End-users and Operator Personnel*

Training the end-user and operations support personnel plays an essential role in rural broadband acceptance, technical maintainability, and ultimately, service sustainability. Planning, preparation, and delivery of an effective training program are complex and challenging activities that require close coordination with many stakeholders across different sectors.

A study of the broadband adoption rate in China found that among the most important factors affecting the adoption rate of broadband Internet access are “disposable income, penetration rate of fixed phones, number of Internet users, and educational attainment” (Nam et al., 2009).

Training depends on the type of end-user receiving it, that is, consumers, small businesses, enterprises, or gateway operators. End-user computer literacy skills (knowing how to use the technology) and local expertise to maintain and repair equipment are critical for sustainability and keeping equipment and service functional.

An effective training strategy should include the following elements:

- Identify key training objectives for both end-users and operations support personnel based on local conditions
- Prioritize (in the project preparation stage) training objectives based on overall broadband service objectives and service rollout phase (deployment, initial service rollout, service take-up) and establish a tiered, high-level plan for training for different levels of expertise
- Provide the same level of mandatory basic training to end-users and operations support personnel alike
- Provide mandatory specialized advanced training to operations and maintenance staff at a central location (e.g., regional service center)
- Ensure regular training intervals for operations and maintenance personnel (e.g., to

address updates on maintenance practices of all installed systems and components)

- Develop and offer free online applications and information technology specific training courses for different types of end-users

The initial basic training for all should cover the following topics:

- Safe operation of equipment (power on or power off)
- Data protection against cyber attacks
- Basic applications and digital literacy (Internet browsing, email, document downloading)
- Professional support in case of an emergency

Part of any training preparation could be a website setup containing basic information on the rural broadband access rollout, progress made, links to relevant educational information, and access to technical education courses. Training could also include training provided in classroom settings in local schools, municipal offices, and local branch offices of the service providers.

## *Joining an Existing System*

Should an end-user consider joining an existing service, the total cost for establishing this access, including equipment cost, installation cost, operations and maintenance cost, and recurring service charges, needs to be considered. Additional cost elements may include the cost of transition and maintenance. From the end-user perspective, the following elements must be defined:

- Internet broadband service cost
- Information about maximum achievable performance and supported applications
- Service quality during adverse weather conditions and other circumstances that may compromise service quality
- Restrictions in the use of the service, such as the amount of data that can be downloaded
- Previous knowledge of existing systems



- Timeline of satellite deployment
- How to procure technical assistance
- Availability of capacity-building programs for end-user training
- Safety and security guarantees

## Consumer Broadband Equipment Providers

To implement broadband technically and operationally, a number of equipment manufacturers and providers have specialized in equipment and services for consumer broadband. The global market for consumer broadband products and services is highly competitive, and there are many different proprietary technology options. Key vendors for VSAT products include Hughes, Gilat Satellite Networks, VT iDirect, and ViaSat. The enterprise market leader is Hughes, followed by Gilat and iDirect. The image below indicates the relative market share of these enterprises based on the total number of terminals shipped in 2012 (ComSys, 2013).

Different VSAT and satellite broadband products from different vendors target different end-users and business requirements. To choose the

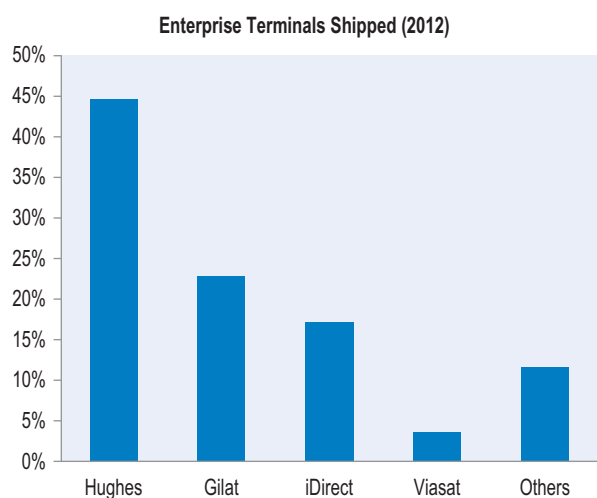
correct product for the business, community, and individual end-users, it is important to understand the attributes of each technology and the desired outcome of the end-user.

Moreover, the industry, regulators, and policymakers have been unable to develop a common and open standard specification for consumer broadband systems that would enable interoperability between systems from different vendors. Consequently, currently operational networks represent a closed architecture from the end-user's point of view. Because open standards and specifications have greatly increased markets in many other industrial areas, ultimately to the advantage of the user, satellite-based broadband needs to open itself to the market in order to be successful.

In selecting products and services for satellite broadband projects, a number of important tradeoff considerations must be considered. These include:

- Location and availability of existing gateway/hub facilities and equipment (potential cost savings, direct access to national communications infrastructure)
- End-user needs (geographic location, throughput, and basic and special applications), and end-user segment (e.g., individuals vs. small enterprise vs. public institutions)
- Business model of satellite operator and service providers and support for OSS/BSS applications (e.g., customer care/help desk, service performance monitoring, service configuration, service billing support)
- Service growth and scalability of hub product (maximum number of supported end-users, maximum data throughput)
- Total cost of ownership (implementation, operation, maintenance and repair, compatibility with existing facilities and systems, integration efforts with other terrestrial communication systems, and training needs)
- Product and service delivery time
- Product flexibility and adaptability to satisfy evolving end-user needs

**FIGURE 4.12 Market Share Enterprise Terminals Shipped, 2012<sup>a</sup>**



Source: Comsys, 2013.

<sup>a</sup> The category "Others" comprises a number of smaller regionally focused providers, for example, IPSTAR in South East Asia.

## SUMMARY AND KEY FINDINGS

The following is a summary of the key findings in this chapter.

For a broadband end-user, the following are the service key elements:

- Value
- Affordability
- Usability
- Maintainability
- Robustness

ISPs have a key role to play in providing these key elements. Therefore, they may have to be regulated to meet service standards and provide nondiscriminatory service, including in rural areas.

The stakeholders in a satellite broadband project comprise multiple players, from areas like policy, regulation, public and private funding, consumer advocacy, and providers of technical facilities and services. Policy and regulation must balance the various interests to the advantage of the consumer.

Funding is a major challenge for rural broadband, considering geography, demographics and low-income consumers.

Subsidies and other public sponsorship include:

- Tax incentives and grants for pilot projects
- CAPEX subsidies for equipment
- Public-private partnerships for free Internet access in public areas

Universal Service Funds (USFs) are widely used to support rural communications. The key elements for establishing USFs are:

- Purpose
- Flexibility
- Transparency
- Independence
- Inclusiveness
- Focus

The Service Level Agreement (SLA) is the key legal and commercial basis defining the relationship between end-user and ISP. This chapter includes certain guidelines, models, and instruments that should be considered when developing SLAs. During planning and initial rollout of a broadband project, the following requirements should be considered:

- Local infrastructure, including electric power
- Local technical knowledge and technical support
- Security, including operational safety, physical security, and cyber security
- Applications and content in the local language
- Applications and information of immediate value to the end-user
- End-users' digital literacy
- Cross-sectoral development programs
- Dialogue between stakeholders
- Project participation of the local community
- Enabling and promotion of participation by local businesses

*Continued on next page*

The network installations directly supporting the broadband end-user are:

- End-user terminal equipment
- Hub/gateway earth station
- Call center/help desk
- Network Operations Center (NOC)

There are a number of vertically integrated providers offering consumer/direct-to-end-user satellite broadband service. All major satellite operators and service providers have identified the LAC region as a key growth region. Major additional satellite capacity for this region is under procurement for deployment within the next two years.

These companies offer proprietary technology. The industry has not been able to agree on an open standard permitting interoperability between equipment from different vendors. Policymakers and regulators may find it advantageous to push for the development of such an open standard.

This Chapter also addresses ancillary aspects of:

- Service quality and availability
- Billing and customer care
- Service quality auditing
- Resource management
- Installation, line-up, and maintenance
- Training
- Electric power supply in remote areas

# 5

## Satellite Broadband Solutions and Selected Examples

---

This chapter describes present and planned satellite broadband solutions, including an analysis of specific programs currently operational in the Latin America and the Caribbean (LAC) and other regions. It provides deployment status and an outlook of telecommunications infrastructure, key broadband systems and programs, and associated elements, including applications served, system capabilities, and technology. Because satellite signals are not limited to areas within national borders, many existing satellite broadband systems are catering to regional markets. While some of the projects analyzed in this study have been targeting specific, geographically limited applications, many networks are designed to serve areas covering many countries.

While satellite operators and broadband service providers are about to enter an era of new technology, specifically with high throughput satellite (HTS), and MEO systems such as like O3b, the current satellite broadband environment in the LAC region tends to use a more traditional service structure. It is important to understand the current state of the industry and the stakeholders involved, including the role played by global, regional, and domestic satellite operators in the LAC region in promoting satellite broadband.

Despite this report's focus on satellite operators, they have not necessarily been at the forefront

of satellite broadband services in the region. Enterprise broadband has largely been shaped by private sector demand factors (in remote areas underserved by terrestrial broadband). Satisfying consumer demand for satellite broadband often requires strong government involvement due to the cost of satellite bandwidth and challenging logistics.

Government-sponsored programs and regulatory universal service obligation (USO) initiatives are generally the drivers of consumer broadband. Services are typically provisioned, installed, and delivered by specialized satellite service providers with domestic expertise and ground infrastructure. Often, the same service provider can address both the enterprise and consumer broadband segments.

The emergence of HTS systems in the LAC region is a positive development, given the important role that they will play in lowering the cost of satellite technology in broadband networks.

Lastly, through the widespread use of smartphones, it is increasingly evident that mobile network operators (MNOs) are becoming Internet service providers (ISP) by default. Hybrid scenarios and systems are emerging in which satellites are used as a "middle-mile" solution to address the digital divide in conjunction with wireless broadband technology.

## General Broadband Service Structure in Latin America and the Caribbean

Satellite broadband in the LAC region is a part of the overall terrestrial broadband access service ecosystem. Commercial users and individual consumers tend to obtain broadband access from either fixed broadband ISPs, MNOs, or both. While the percentage of users served by each player varies by country, the same general principles apply to the entire region.

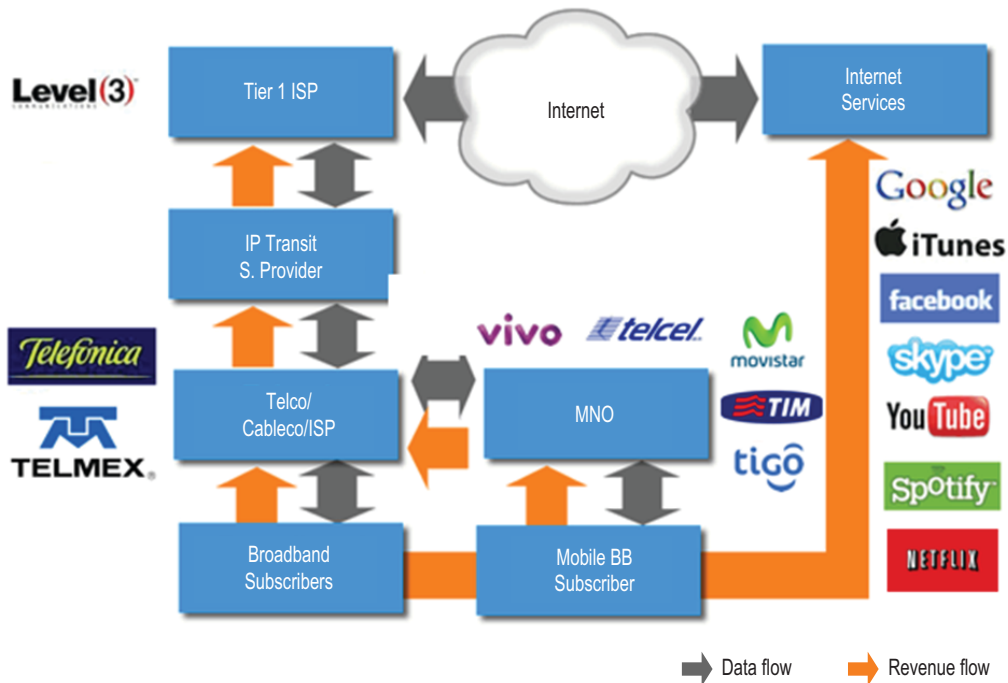
Given the lack of local-loop unbundling legislation (or poor enforcement where such legislation exists), ISPs providing fixed broadband access in the region are either telecom operators (so-called Telcos), generally via Asymmetrical Digital Subscriber Line (ADSL) broadband technology, or cable TV operators (Cablecos or multi-system operators (MSOs) via cable modem technology). Naturally, these players tend to deliver such services as bundles that may include TV and telephony.

Figure 5.1 provides an overview of the terrestrial broadband access service ecosystem, including the main players, interrelationships, and revenue flow.<sup>17</sup>

During the early days of the Internet, ISPs such as El Sitio, Terra, and others served the region. Presently, Telcos and Cablecos largely dominate broadband access. Thus, “Telcos” and “Cablecos” tend to be the conventional, fixed broadband ISPs. While small in comparison to the established players, there are, nevertheless, organizations such as NGOs and nonprofit cooperatives that manage and provide broadband access in lower-density locations via either ADSL or cable modem technology.

<sup>17</sup> Note that the picture also includes how revenue can flow to the so-called “Over The Top” (OTT) Internet players including Netflix and others, which piggyback on the principle of Internet Net Neutrality, gaining revenue from Internet users without ownership of last mile network resources.

**FIGURE 5.1** Terrestrial Broadband Ecosystem



Source: ITSO.

MNOs in the LAC region tend to be sister companies of Telcos, and they sometimes bundle services across fixed and broadband networks. With a few exceptions, Telcos and MNOs in the region are generally large, well-established companies with operations in multiple countries. The following telecom groups, Telefonica/Movistar and Telmex/America Movil, as well as Digicel and Cable and Wireless in the Caribbean, dominate fixed and mobile services across the region.

Understanding the general broadband structure in the region is of great importance for satellite broadband. Even if satellite broadband networks are integrated and managed by other players, Telcos and MNOs tend to be excellent candidates for distribution agreements because of their extensive networks, local market knowledge, and retail resources.

### Satellite Broadband Ecosystem in Latin America and the Caribbean

Given the LAC region's satellite broadband ecosystem, there are common patterns among the businesses of satellite operators. Essentially, any satellite operator, large or small, regional or domestic, has the capability to provide satellite spectrum for broadband access. There are, nevertheless, differences in geographic and demographic focus and technical strengths and weaknesses.

While a number of traditional satellite operators dominate the LAC region, only two operators with limited HTS capacity, namely Telesat/ViaSat, currently offer limited HTS technology through the Anik-F2/WildBlue-1 satellite. This satellite offers coverage over the northern part of Mexico, and Hispasat, which offers coverage in a number of South American countries on the Amazonas-3 satellite, launched in mid-2013. Several more players will enter the market in the coming years.

The following are a few industry highlights concerning satellite bandwidth in the LAC region, and HTS in particular:

- Eutelsat, with Eutelsat-3B. Eutelsat-3B will offer HTS capacity over Brazil.
- Inmarsat, with Inmarsat-5F2 being part of their "Inmarsat Global Xpress" (IGX) program, focuses on applications such as commercial mobility and government /military.
- The Bolivian Space Agency launched TKSat-1 in 2014, which offers wide beam Ku-band capacity as well as limited HTS coverage over Bolivia, with additional non-HTS capacity offered regionally.
- Intelsat will be launching Intelsat-29e in 2015-2016 as part of its Intelsat Epic<sup>NG</sup> program. Intelsat-29e will offer Ku-band HTS capacity over every country in the Americas, with emphasis on the Caribbean and South America. Intelsat also plans to launch IS-35e in 2017 with C-band spot beam capacity over Latin America.
- Hispasat will expand its presence in Latin America with the launch of Amazonas-5. This satellite could offer significant HTS capacity over Mexico, in addition to other key markets in the region, such as Brazil, Argentina, Chile, Colombia, Peru, and Ecuador.
- Star One will enter the HTS race in 2016 with the launch of Star One-D1, which will offer significant capacity over Brazil, and to a lesser degree in Colombia, Venezuela, and Ecuador.
- Telebras will launch its SGDC-1 satellite in 2016.
- Eutelsat could further strengthen its position in the Latin American HTS market with the 2016 launch of Eutelsat-65W A.
- ViaSat and Hughes are expected to launch ViaSat-2 and Jupiter-2, respectively, in 2016, which are estimated to have tens of Gigabits per second (Gbps) of regional HTS capacity each, concentrated over Mexico, Central America, and the Caribbean.

### Selected Country-specific Examples of Satellite Based Solutions

In order to illustrate the principal satellite broadband trends described above, the following

section provides examples of selected satellite-based broadband services in Colombia, Brazil, and Australia.<sup>18</sup>

All major satellite operators and service providers have identified the LAC region as an important market for future business growth. Global fixed-satellite service (FSS) providers, such as Intelsat, SES, Eutelsat/SatMex, Telesat, as well as several more regionally focused companies such as Hughes/Echostar, DirecTV, StarOne/Embratel, Hispasat/Hispamar, and Asia Broadcast Satellite/ABS, have operational satellites in place with beams covering the LAC region. These satellites provide significant C-and Ku-band capacity in addition to a small but increasing Ka-band capability. All satellite operators have plans to add significant capacity by 2016–2017. Likewise, it is expected that either Hughes or ViaSat (or both) will deploy substantial Ka-band capacity over Mexico, Central America, the Caribbean, and perhaps over the Northern part of South America.

Other global satellite operators, including O3b Networks and Inmarsat's Global Xpress (GX), are currently deploying satellite systems for high-speed Ka-band satellite capacity. However, the target markets for both GX and O3b are unique. O3b focuses on fiber-like high data rate backbone and backhaul links (to ISPs and cellular telephone providers), while GX is largely focused on mobility applications, including maritime, aeronautical, and government/military.

The satellite industry is in the midst of a global transition toward HTS platforms that are intended to improve the economics of satellite broadband.

#### IMAGE 5.1 Vive Kiosko Digital in a Colombian School



Source: Government of Colombia, 2014.

Existing examples represent the past and do not necessarily reflect future opportunities that are expected to materialize through HTS technology.

#### *Kioscos Digitales in Colombia*

In mid-2014, Colombia's Ministry of Information and Technology (MinTic) launched a US\$10 billion nationwide four-year effort (Vive Digital) to triple Internet connections from 8.8 million in 2014 to 27 million in 2018. An integral part of Colombia's Vive Digital Plan is to establish Internet access points (*Kioscos Digitales*) within communities and schools in rural and remote areas. The goal is to provide Internet access to all communities with more than 100 people. The Vive Digital kiosks provide Internet connection as well as other ICT and mobile services (Figure 5.1).<sup>19</sup>

In 2014 Colombia's MinTic awarded contracts to four consortia, each led by a company with a strong presence in the country, to establish over 5,500 such access points:

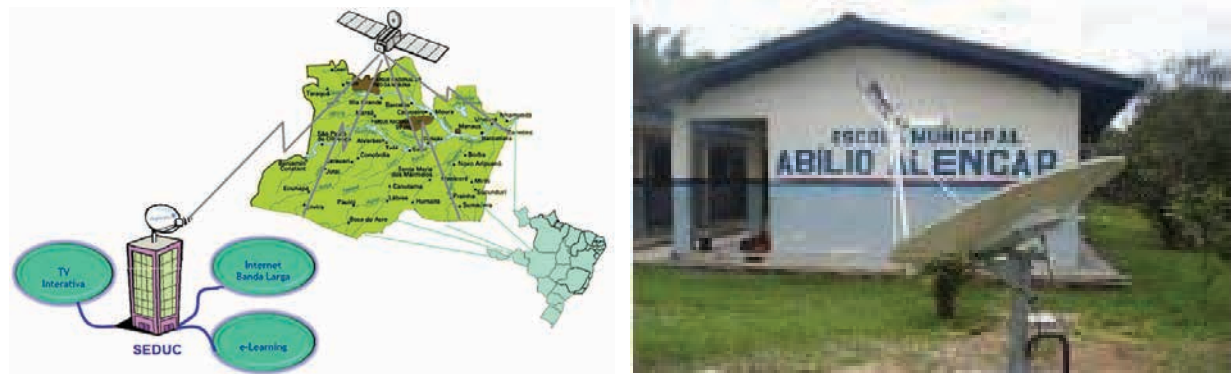
- Gilat Colombia: to deploy 1,903 VSATs using Gilat's own SkyEdge II technology. Gilat collaborated with Intelsat to provide Ku-band satellite capacity.
- NEC de Colombia and Hispasat: to build 648 digital kiosks. Hispasat in turn selected Hughes' HX Broadband System as VSAT platform provider.

<sup>18</sup> These three countries have been randomly selected. The fact that certain companies and their products are mentioned in the following paragraphs does not constitute an endorsement by this study in any way. These companies, their products and services are examples of how satellite based broadband services have been used to bring broadband Internet access to rural communities as quickly as possible, to expand or complement existing communications infrastructure, and to contribute to economic development in rural areas. Moreover, these examples do not comprise an exhaustive list of all comparable projects in place today, or planned.

<sup>19</sup> See <http://www.intelsat.com/intelsat-news/gilat-utilizes-intelsat-satellite-services-to-deliver-broadband-connectivity-to-schools-and-communities-in-rural-colombia/>.



**FIGURE 5.2** Brazilian Rural Broadband for Distance Learning



Source: Centro de Mídias de Educação do Amazonas, 2015.

- Unión Temporal Internet para Kioscos (Anditel y Acción, S.A): to build 1,220 digital kiosks.
- Unión Temporal KVD (TV Azteca, Total Play): to build 1,753 digital kiosks.<sup>20</sup>

After successfully setting up and inaugurating such digital access points, initially, the kiosks functioned normally. However, later on, the project experienced problems due to lack of supplies (e.g. no printer paper and ink), poor connectivity, and nonpayment to suppliers and kiosk operators (*Vanguardia*, 2013).

### **The SEDUC Program in Brazil**

HughesNet® has partnered with the government of the State of Amazonas, Secretariat of Education (SEDUC), to provide satellite broadband for educational purposes to rural regions. The State of Amazonas is the largest and one of the most rural states in Brazil, with about 6,100 communities in remote locations.<sup>21</sup>

The SEDUC satellite broadband project brought an interactive learning experience to over 20,000 students in 300 rural schools. This project uses the Brazil-wide HughesNet® satellite service in addition to IPTV (television over IP protocol) to transmit classes to rural areas. The project also required installation of Diesel generators at remote locations without electricity. The classes are taught

in a media center in the state capital of Manaus and then transmitted to over 700 classrooms all over the primarily rural state of Amazonas, as shown in the Figure 5.2.<sup>22</sup>

### **SGDC Program in Brazil**

The Defense and Strategic Communications Geostationary Satellite (SGDC) System, or Brazil's SGDC program, addresses communications needs of the federal government, including the National Broadband Program (PNBL) and strategic defense communications. During the 2014 VSAT Latin America event in São Paulo, Visiona Tecnologia Espacial and Telebras shared details about Brazil's government satellite program included here. The first satellite (SGDC-1), to be launched in 2016, includes a multi-purpose, extensive Ka-band payload with spot beams across Brazil, and X-band capacity (Figure 5.3).

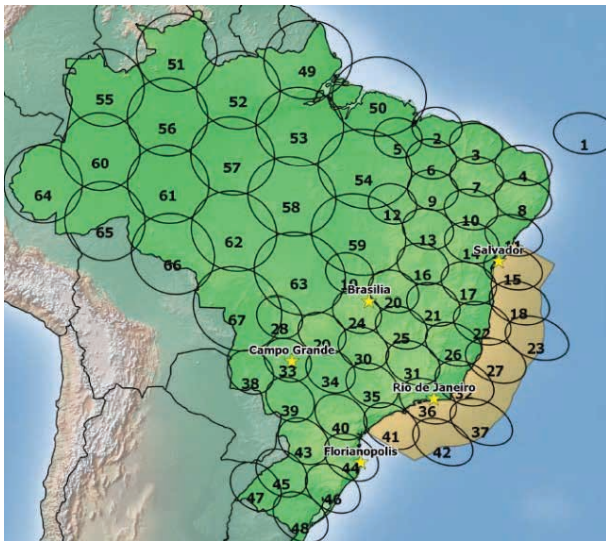
Based on Thales Alenia Space Spacebus-4000 platform, the SGDC satellite is expected to operate

<sup>20</sup> See <http://colombiadigital.net/actualidad/noticias/item/6208-el-programa-vive-digital-fase-ii-entregara-5-524-kioskos-digitales.html>.

<sup>21</sup> There is a SEDUC Program financed by the IDB in the State of Amazonas. See Program to Accelerate Educational Progress in Amazonas State (PADEAM). Inter-American Development Bank. Document BR-L1328.

<sup>22</sup> See <http://www.centrodemidias.am.gov.br>.

**FIGURE 5.3 SGDC-1 Coverage Map**



Source: Telebras, 2014.

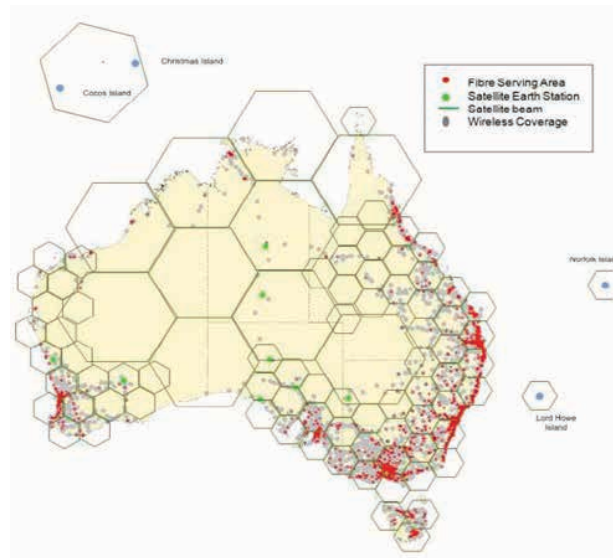
at the 75° West orbital location. Telebras aims to use the satellite to reach underserved regions that are overlooked by commercial operators, including more than 2,000 municipalities or cities without fiber to transfer information on the ground. SGDC will bring wideband Internet capacity to these cities. Most of them are located in the northern region, where there is low population density and a complex environment to transfer data by fiber. Telebras is currently evaluating whether a second SGDC satellite will be needed.

### **NBN Co. in Australia**

NBN Co., a state-owned enterprise in Australia, provides access to fast, reliable, and affordable broadband services throughout Australia. NBN Co. plans to accomplish this using a mixture of access technologies, depending on each area. These include terrestrial access, including hybrid fiber-coaxial (HFC), wireless technologies, and satellites.

NBN Co. is set to launch two next-generation Ka-band satellites to provide access to areas outside fiber and fixed wireless footprints (Figure 5.4). The satellites, one launched in 2015

**FIGURE 5.4 NBN Co. Satellite Coverage**



Source: Parliament of Australia, 2011.

and another planned for 2016, will provide high-speed broadband coverage to around 3 percent of the land area, including outback areas and Australia's external territories, such as Norfolk Island, Christmas Island, Macquarie Island, and the Cocos Islands.

NBN Co. plans to use a combination of Ka-band spot and wide beams with frequency reuse to cover the entire Australian territory. It is expected that demand on the east and west coasts will saturate the beams in those areas, the reason why NBN Co. will also be expanding wireless and terrestrial access when economics justify the investment.

NBN Co. will mainly be a consumer-grade broadband platform, although business premises can and will likely leverage the service. Since NBN Co. will most likely have excess capacity based on the 3 percent premises target mentioned above and the geographic coverage it is planned to serve, NBN Co. could also serve business premises in remote and underserved locations, where mining and oil and gas industries are located. As such, excess capacity will have to attract other customers, with the consequence

that the economic gap between traditional satellite capacity and HTS will likely mean some level of business loss for traditional players in Australia. NBN Co. is a residential broadband platform and a national satellite program, due to the strong government involvement.

## Regional and Global Examples of Satellite-based Solutions

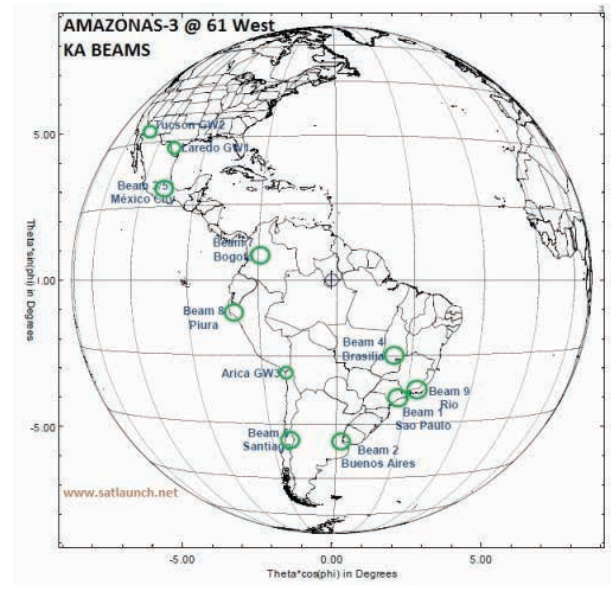
### Media Networks Latin America

Telefonica's Media Networks Latin America (MNLA) is the first, and currently the only, operator with HTS capacity available over South America, with a hosted payload (fully owned, not leased capacity) in the Hispasat Amazonas 3 on the 61W orbital slot (Figure 5.5). The prime focus of Amazonas 3's HTS payload was to offer residential broadband in suburbs of the major metropolitan cities of Latin America at speeds of 2Mbps, thus competing in geographic areas where fiber optic cables are a strong competitor. The Amazonas 3 satellite has nine spot beams over seven countries, with Brazil hosting three beams, Mexico hosting two beams, and Colombia, Peru/Ecuador, Argentina, and Chile hosting one each. The Argentina beam is not in use because Hispasat has been unable to secure landing rights for Ka band in that country.

Although the entire estimated 10–12 Gbps of HTS data throughput on Amazonas 3 was pre-sold to MNLA for consumer broadband service, the business case cannot be considered a complete success for consumer broadband because the number of customers signing up for this service has been fewer than expected. Consequently, MNLA is currently considering other uses for the capacity, including wireless and fixed broadband backhaul (middle mile).

The MNLA Ka-band network and its potential expansion via the addition of capacity on the Amazonas 5 satellite is a clear example of a residential broadband satellite system. While satellite spot-beam coverage is not as comprehensive as coverage in the United States and Europe (i.e.,

**FIGURE 5.5 Media Networks Coverage Map**



Source: Hispasat, 2015.

HughesNet and Eutelsat Ka-SAT), the network topology and service architecture are very similar. The main difference is how such service is commercialized given that MNLA adopted a wholesale, “white label” service model and relies on a network of retail partners such as Telcos and mobile networks operators, rather than the model used by companies such as Hughes, which occupy a larger segment of the value chain by providing end customer service themselves.

### Eutelsat's Expansion into Latin America

Eutelsat is one of the largest satellite operators, but its presence in Latin America has been historically limited. However, Eutelsat appears to have taken a decisive approach toward expanding its presence in Latin America due to the acquisition of Satmex, the Mexican satellite operator.

To date, Eutelsat Americas' business has been largely linked to the operations and markets served by SatMex. Eutelsat Americas is aggressively expanding its footprint in the region and is taking a pragmatic approach.

In 2014, Eutelsat Americas' business surged thanks to a major deal with its Brazilian division. Eutelsat do Brasil signed a contract with Hughes Network Systems do Brasil for all of the Ka-band capacity allocated to the Brazilian service area on the upcoming HTS Eutelsat 65 West A. The agreement included the entire satellite Ka-band capacity for Hughes do Brasil for 15 years and closely followed the renaming of Satmex to Eutelsat America. The footprint of this satellite has not yet been published.

Although Eutelsat is a traditional satellite operator, as evidenced by its KASAT satellite in Europe, it is also able pragmatically to adopt different business models as needed. Based on regional market dynamics, Eutelsat's first HTS satellite in Latin America is both open and closed, but the partnership with Hughes do Brasil will clearly push it to a vertically integrated residential broadband play.

### ***HughesNet and ViaSat in Mexico, Central America, and the Caribbean***

Mexico, in particular northern Mexico, was served by HughesNet services through a distribution deal with Pegaso Banda Ancha, a Grupo Pegaso company. However, this service is not included in the

new Spaceway-3 or Jupiter-1 satellite capacity, but HughesNet's conventional Ku-band satellite broadband service has been available for years.

In March 2015, Pegaso Banda Ancha entered into a new agreement with HughesNet for the turn-key delivery of a Hughes Jupiter Gateway and more than 5,000 VSATs to connect remote communities and schools, which currently do not have broadband Internet access (PR Newswire, 2015). The Bicentenario satellite service, owned by Mexico's Secretariat of Communications and Transportation (SCT), will deliver the service.

Although the details are not known, it is estimated that the Jupiter technology could offer between 5 Gbps and 15 Gbps of HTS capacity. This, combined with the existing and planned offerings by ViaSat, could increase competition in the region's residential broadband market. Furthermore, Hughes/EchoStar is expected to be very competitive in pricing for its broadband service, which will put further pressure on the market.

Overall, it is almost certain that HughesNet and its parent company, EchoStar, will attempt to compete in the rapidly developing consumer broadband market in Mexico via Jupiter technology, and compete with ViaSat.

Detailed coverage maps by either HughesNet or ViaSat for their upcoming Jupiter-2 and Viasat-2 satellites have not yet been published, but it is highly likely that at least one of these two leading HTS players will deploy substantial Ka-band spot beam capacity over Mexico, the Caribbean, and Central America (Figure 5.6). To put these plans in the context of the models described earlier, such plans will fall into the residential broadband category. Outside of Mexico, there will likely be a focus on mobility applications, such as maritime and aeronautical communications, particularly in the Caribbean.

### ***Intelsat Epic<sup>NG</sup>***

Although it does not currently offer regional HTS capacity, Intelsat is nonetheless the global leader in overall C and Ku-band satellite capacity, and it already has a very strong presence in

**FIGURE 5.6** ViaSat-2 Preliminary Coverage Map



Source: ViaSat, 2015.



Latin America. Historically, Intelsat has had close relationships with major Telcos, broadcasters, and mobile operators.

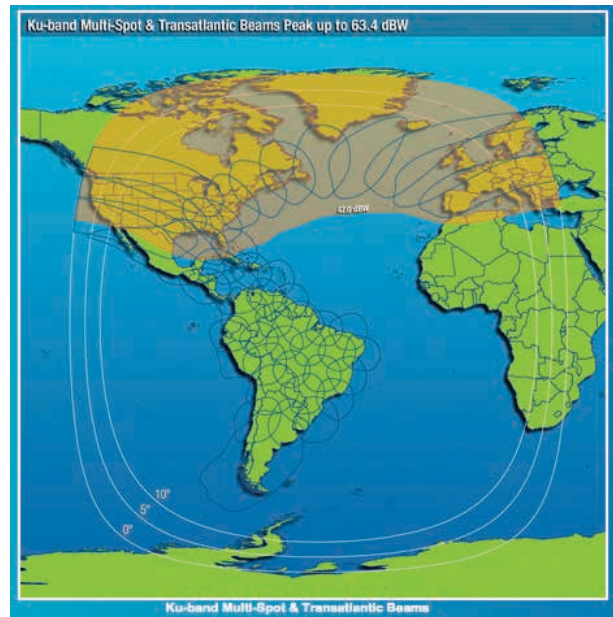
Intelsat will enter the HTS market in Latin America in 2016 through the expected launch of Intelsat-29e, one of the several satellites currently planned to comprise Intelsat Epic<sup>NG</sup>. Epic<sup>NG</sup> aims to become a global network of HTS coverage. For Latin America, Intelsat plans to launch the IS-29e with Ku-band HTS capacity, and the IS-35e with C-band spot beam capacity, in 2017.

The Intelsat Epic<sup>NG</sup> platform represents a new approach to HTS satellite and network architecture, utilizing Ku and C-bands (Figures 5.7 and 5.8), wide beams, spot beams, and frequency reuse technology to deliver more speed per unit of spectrum. Designed as a complementary overlay, Intelsat Epic<sup>NG</sup> is fully integrated with Intelsat's existing satellite fleet and global IntelsatOne terrestrial network.

Perhaps the most interesting aspect of Intelsat Epic<sup>NG</sup> is that it claims to be based on an open architecture and engineered for backwards compatibility, allowing communications, media and government organizations to realize high-throughput performance utilizing their existing hardware and network infrastructure. While the promise of an open approach encourages traditional satellite service providers to transition to HTS via Intelsat, it is unclear if, over the longer term, Intelsat may be forced by the architecture itself to compete against some of its traditional clients.

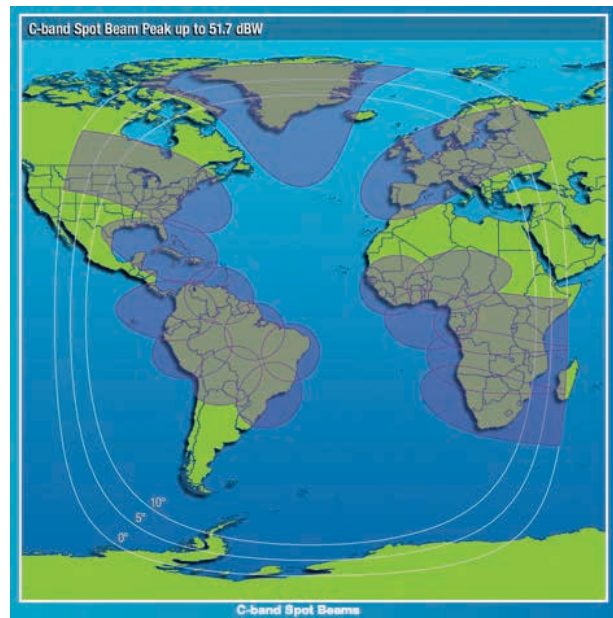
Nevertheless, Intelsat has a new leapfrog opportunity with Epic<sup>NG</sup> if Intelsat were to embrace ambitiously the potential of virtualization. In the context of shifts across the satellite value chain, Epic<sup>NG</sup> could lead to the creation of a new services framework that encourages and rewards infrastructure sharing and new service creation. Intelsat could use its high-throughput global network as a low-level building block toward driving higher-layer services and reshaping the way satellite services are conceived and delivered. A cooperative, service-oriented architecture that incorporates modular reusable services with standardized interfaces

**FIGURE 5.7 Intelsat 29e at 310° E. Ku-band Spot Beams**



Source: Intelsat, 2015.

**FIGURE 5.8 Intelsat 35e at 325.5° E. C-band Spot Beams**



Source: Intelsat, 2015.

could support and empower service providers to craft differentiated services cost-effectively. The remarks made by Intelsat CEO, Mr. Stephen Spengler, in the Intelsat blog, in anticipation of

Intelsat's participation at CommunicAsia 2015, seem to reinforce the direction described above (Spengler, 2015; Tanner, 2015).

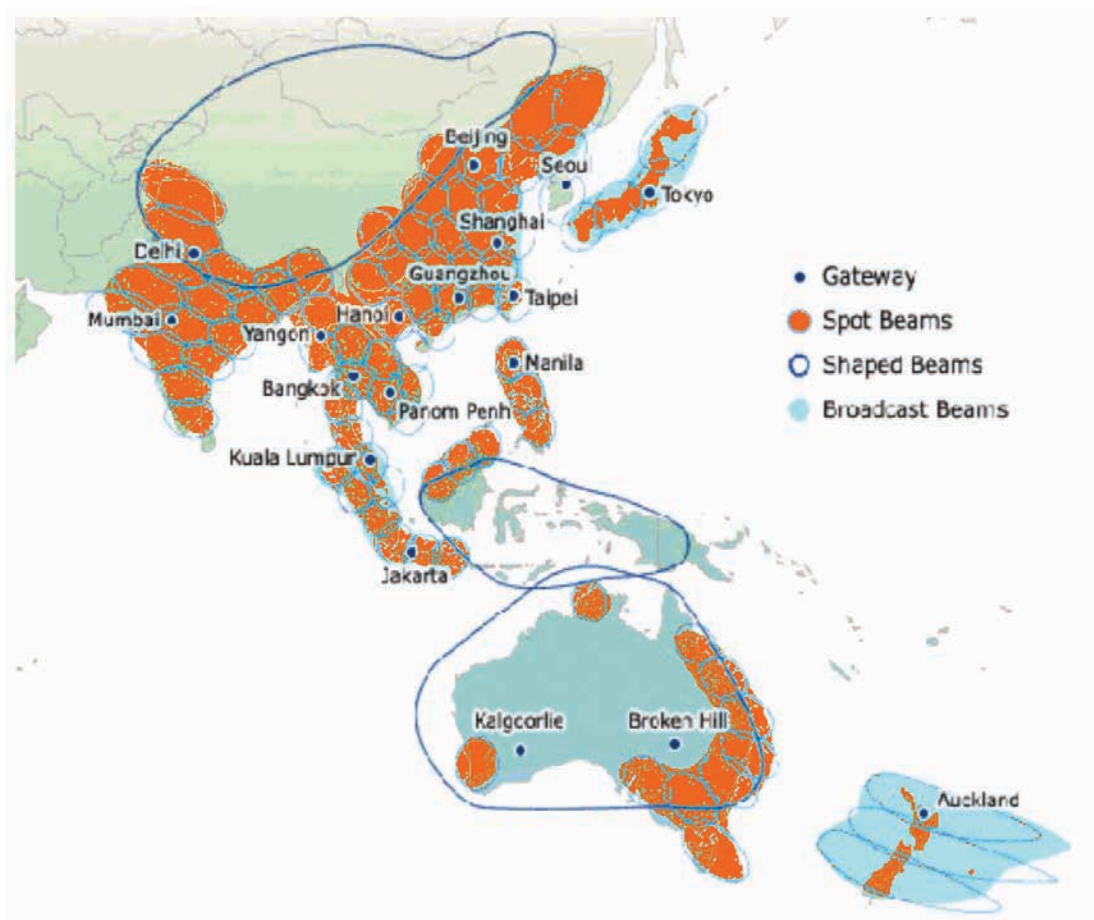
Intelsat Epic<sup>NG</sup> is the clearest example of an open HTS system. The primary uses of Epic<sup>NG</sup> will be empowering existing service providers to transition to HTS to serve enterprise VSAT, mobility applications (maritime, aero), and wireless backhaul (middle mile).

### IPSTAR in Asia

The Thaicom 4 (IPSTAR-1) is the first Ku-band HTS ever launched (Figure 5.9). Launched in August 2005, this satellite was the heaviest commercial

communication satellite ever launched up to that point. It provides businesses, government administrations, and telecom operators in the Asia-Pacific region with cost-effective satellite broadband capacity and services. It is the precursor and prototype of all presently available and planned HTS spacecraft with respect to the technical and operational principles related to this technology. With around 45 Gbps of total capacity, IPSTAR's broadband satellite network was designed for high-speed, two-way IP broadband communication. It achieves high-throughput connectivity through a combination of Ku-band spot beams over densely populated areas and zone beams for lower-density regions.

**FIGURE 5.9** IPSTAR-1 Coverage Map



Source: Thaicom, 2015.



IPSTAR is a wholly owned subsidiary of Thaicom Public Company Limited, an important general telecommunications provider in South East Asia. It is an excellent example of the changes currently shaping the satellite industry. Well ahead of its time at the beginning of service in 2005, IPStar's business did not initially achieve the anticipated market acceptance because of a combination of factors that included a lack of equipment for the end-user, a less-than-perfect service distribution structure, and the absence of landing rights in the countries covered.

As a pioneer in HTS, IPSTAR had to research, design, and develop its own ground network technology, given that there were no commercially available HTS ground systems that could interact efficiently with the powerful THAICOM-4 satellite. IPSTAR pioneered some techniques that are widely used today. An example is a bandwidth management technique called "adaptive coding and modulation" (ACM) used to convert the "rain margin" into higher data throughput when the broadband satellite terminals are under clear sky conditions.

IPSTAR's pioneering of HTS led to a proprietary network architecture and commercial distribution channels with a vertically integrated service model, also known as "closed" HTS model. This, together with the fact that IPSTAR did not anticipate the complexities of obtaining landing rights and developing effective sales pipelines for all the countries covered, hindered its rapid adoption.

More recently, however, satellite fill rates have increased substantially because IPSTAR opened its satellite capacity for use with ground systems from other manufacturers and vendors. Consequently, commercial distributors are now able to take full advantage of HTS satellite resources with their technology of choice. In a sense, IPSTAR is the best worldwide example of a large HTS system that has transitioned from a closed to an open business model with a good degree of success. In addition, IPSTAR's business achievement would not have been possible without the active involvement of

telecommunication regulators, who have granted it landing rights in many countries throughout the region and permitted the operation of gateway earth stations.

### O3b Networks

O3b Networks offer MEO (Medium Earth Orbit) services worldwide, with emphasis on developing regions, including the LAC region. O3b's system architecture involves 10 Ka-band beams per satellite of up to 700km in diameter. Each beam delivers up to 1.2Gbps.

With two gateways in South America and one in the southwestern United States, O3b is clearly trying to cater significantly to the Latin American market. Furthermore, with coverage spanning the entire LAC region, except for the southern tip of South America, O3b has the ability to provide pan-regional services.

O3b is a satellite constellation platform clearly developed for the middle mile, offering fiber-like speed and reduced latency. It primarily targets backhaul, trunking, and commercial mobility services, and it is expected to carve out its own market niches.

O3b still faces several challenges for growth, including the complexity and high cost of the antennas needed on the ground (tens of thousands of dollars each) to deal with the satellite handoff process described earlier in this report. Nevertheless, O3b's business model has several advantages beyond low latency and high speed. It is not yet a major HTS player but could become one in the LAC region in the medium to long term. O3b has already made solid inroads into markets such as the Caribbean (on cruise ships) and Brazil, which granted it regulatory approval to provide services.

O3b is an alternative for high-speed middle mile, but it does not clearly fall in any of the categories described above because of its unique fiber-like value proposition. Considering the high costs of its terminals, O3b is not a solution for last-mile broadband access.

## Looking Ahead: High Throughput Satellites for the LAC Region

The provisioning of end-to-end satellite broadband services still relies on traditional ecosystem that is mainly composed of service providers (SP), satellite operators (SO) and ground system vendors.

In the LAC satellite broadband service ecosystem, broadband SPs tend to:

- Lease slots of satellite spectrum band (raw bandwidth in MHz) from one or more satellite operators;
- Be general telecommunications operators, or specialized satellite service providers that exclusively focus on mastering satellite services;
- Interface with technology vendors and select one or more satellite broadband ground systems that make efficient use of the leased satellite spectrum;
- Do installation, in-house integration, packaging, and provisioning of satellite connectivity services; and
- Market, sell, provision, and maintain such services offered to internal or external end-users.

The satellite broadband structure in the LAC region uses traditional satellite resources to provision and deliver end-to-end broadband services. To a large degree, traditional satellite systems are designed to serve broadcast users cost-effectively in C and Ku-band. However, they have presented economic barriers for the satellite broadband market given intrinsic differences in how bandwidth is used for television, their core business, and the emerging broadband market.

The regional distribution structure is expected to change in the near future because of the launch of HTS satellite systems, a new generational breed of satellites that via small beams and frequency reuse, aim at easing or eliminating cost barriers to bridge the digital divide more effectively.

Indeed, the LAC region seems to be in the early stages of what is poised to become a dynamic and

competitive HTS marketplace.<sup>23</sup> On the demand side, bandwidth-hungry applications, such as residential broadband, 3G/4G data backhaul/offload, and mobility (maritime/aero) have long been awaiting the emergence of lower-cost platforms to enable economic operation.

Meanwhile, an increasing number of satellite operators have committed to deploy substantial HTS capacity in the 2016–18 period. This means that there could be scenarios of oversupply in specific spots, and that supply-side economics could drive the evolution of the Latin American HTS market in some markets.

Nevertheless, what makes the LAC region interesting is the diverse set of emerging HTS architectures and business models and the range of players driving them. These new systems will imply modifications to the traditional satellite value chain at both regional and country-specific levels.

Despite some inevitable overlapping among the network architectures and target markets proposed by the satellite operators, HTS platforms in the region tend to fall into three broad categories, based on their respective primary targets:

- Residential broadband
- National satellite programs
- Open business-to-business platforms

### Residential Broadband

The Latin American and Caribbean HTS residential broadband segment is at an embryonic stage, but is projected to become a high-growth “volume” market, with most of the growth starting in 2016. Northern Sky Research (NSR) forecasts that by 2022, there will be over 620,000 HTS broadband subscribers. This will almost triple the current installed base of broadband VSATs used across the region for enterprise-class services via traditional Ku-band capacity.<sup>24</sup>

<sup>23</sup> See <http://satcompost.com/key-trends-for-the-emergence-of-hts-platforms-in-latin-america>.

<sup>24</sup> See [http://www.nsr.com/upload/research\\_reports/nsr\\_bbsm10\\_brochure\\_heh.pdf](http://www.nsr.com/upload/research_reports/nsr_bbsm10_brochure_heh.pdf).

Residential satellite broadband systems generally need to place a satellite terminal at the user's premises, which is more economical and favors a vertically integrated approach for all functions traditionally carried out by satellite operators and service providers. Furthermore, use of Ka-band spot beam satellite technology with frequency reuse tends to dictate the architecture be designed with a rather closed approach, which can drive the system to achieve the highest levels of efficiency, both in terms of bits per Hertz of bandwidth and traffic overbooking.

Although limited in scope, there is already HTS experience in Latin America. MNL A began commercial operations of the first regional HTS network via a HTS payload aboard Hispasat's Amazonas 3 satellite. With more than 12Gbps of aggregate IP data throughput, distributed across nine spot beams, covering some of the region's most populous metropolitan areas, MNL A's main target is clearly the residential broadband market.

Similar to how MNL A approached the direct-to-home television market, it has adopted a wholesale, white-label HTS service distribution model. MNL A took charge of procuring, deploying, integrating and operating the hybrid broadband infrastructure, so that service distributors could rely on this infrastructure to sell and brand their own services without the need to deal with the complexities of managing core network resources.

### **National Programs**

Some countries in the region, including Argentina, Bolivia, Brazil, Mexico, and Nicaragua, are actively seeking technology independence through government-funded space programs for the design, construction, and operation of national communication satellites, often with hybrid FSS/HTS payloads. Early in 2014, the Bolivian TKSat-1 satellite, manufactured under the terms of a cooperative agreement between Bolivia and China, entered geostationary orbit with a limited number

of spot beams. Argentina's state-owned operator ARSAT also has plans to include Ka-band spots in the future, but Brazil's satellite program is the best example of how large and relevant national programs can be for domestic HTS markets.

The Brazilian Defense and Strategic Communications Geostationary Satellites (SGDC) are purposely designed and built to provide Brazil with independence from the commercial satellite sector to meet strategic defense and civilian and social inclusion objectives. The first SGDC satellite (SGDC-1), expected to be launched in 2016, will have X-band capacity for defense applications and will host a large multi-spot-beam Ka-band payload with an estimated capacity of over 40Gbps, to be used to bridge the "middle mile" digital divide in key areas of the country.

### **Open System Satellite Platforms**

Open System Satellite Platforms are the commercial model and network architecture category in which most of the traditional Latin American FSS satellite operators, including Intelsat, Telesat, StarOne, will be. With the first of the series of Intelsat Epic<sup>NG</sup> satellites (IS-29e) scheduled for launch in 2016, Intelsat will be the operator leading the way for "open" HTS B2B service models.

Considering Intelsat's conservative business strategy in the past, Epic<sup>NG</sup> is truly an evolutionary progression of the traditional model of satellite transmission capacity leased to service providers that use capacity such as raw material to create their own differentiated service offerings. Initial focus is on Ku-band spot beams ensuring a good degree of backward compatibility for traditional service providers and legacy ground systems.

Such a natural progression is vital for the sustainability of non-broadcast B2B satellite applications such as backhaul. Challenges include the expansion of terrestrial networks and the transition from a voice-dominated to a data-dominated mobile environment with inherently lower average revenues per user (ARPU).

## SUMMARY AND KEY FINDINGS

The following is a summary of the key findings in this chapter.

In the LAC region, Internet service providers (ISP) and mobile network operators (MNO) provide satellite broadband service. Satellites are the “middle-mile” solution to the digital divide.

Satellite operators in the LAC region include:

- Telesat/Viasat
- Hispasat
- Eutelsat
- Inmarsat
- Intelsat
- Star One
- Telebras

Only Telesat/Viasat and Hispasat offer High Throughput Satellite (HTS) technology.

In mid-2014, the Colombian Ministry of Information and Technology launched the Vive Digital project to triple Internet connections by 2018 through the installation of Internet access points (Kioskos Digitales).

The State of Amazonas Secretariat of Education (SEDUC) partnered with HughesNet® to provide e-education services via satellite broadband in rural areas. Over 20,000 students in 300 schools are benefiting from this project.

In Australia, state-owned enterprise NBN provides access to fast, reliable, and affordable broadband services throughout Australia. NBN relies on satellites to accomplish this task. It will use satellites to cover around 3 percent of the premises, including outback areas and Australia’s external territories.

In Asia, IPSTAR provides cost-effective satellite broadband capacity and services through Ku-band HTS technology to the Asia-Pacific region.

Worldwide, O3b Networks offers MEO (Medium Earth Orbit) services worldwide, with emphasis on developing regions, such as the LAC region.

The regional distribution structure will change in the next few years with the development of HTS systems.

In the LAC region, several broadband service providers are implementing satellite technology to gradually eliminate the digital divide:

- Media Networks Latin America (HTS capacity)
- Eutelsat (Ka-band capacity),
- HughesNet and ViaSat (Ku-band and HTS capacity),
- Intelsat Epic<sup>NG</sup> (HTS, Ku-band, and C-band capacity)

# 6

## The Focus Countries

---

The preceding chapters have explained satellite broadband principles, operational and planned systems, technology trends, and end-user concerns. This chapter analyzes the potential role of satellite systems in bridging the digital divide. Four countries—Argentina, Nicaragua, Peru, and Trinidad and Tobago—were selected at random for analysis. The four focus countries are meant as examples, and as such are not meant to represent countries that are better suited for satellite broadband than any other countries.

The vast majority of satellite broadband providers are not only targeting individual countries; they operate on a regional or sub-regional basis. While most cable projects cover specific, geographically confined markets, satellite signals do not end at national or regional boundaries. Consequently, satellite broadband technology is universally useful and should be used to narrow the digital divide throughout the LAC region.

The analysis of each of the focus countries includes an introduction, which summarizes geographic, demographic, and socioeconomic aspects. It also looks at broadband trends in each country, including the metrics for fixed and mobile penetration and a description of their respective competitive telecom environment, main telecom players, and general industry dynamics. It analyzes and describes each country's regulatory bodies and framework, their public-private interplay, and their national broadband plans (where they exist).

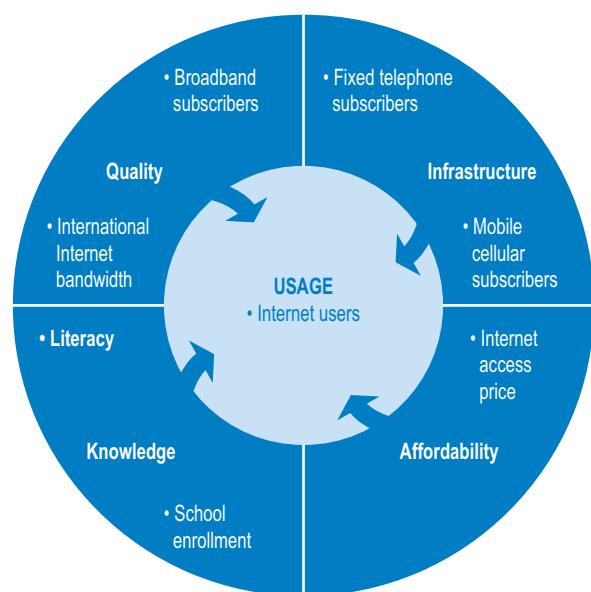
Finally, the chapter proposes solutions and key recommendations for each focus country concerning the use of satellites to bridge the digital divide, in the specific context of domestic dynamics and global satellite market trends. These trends include the transformation of the global satellite communication industry through the introduction of high-throughput satellite (HTS) systems for the cost-effective delivery of one-to-one applications, such as broadband access and cellular access backhauling.

### The Focus Countries from a Global Perspective

#### *The International Telecommunications Union's Digital Access Index*

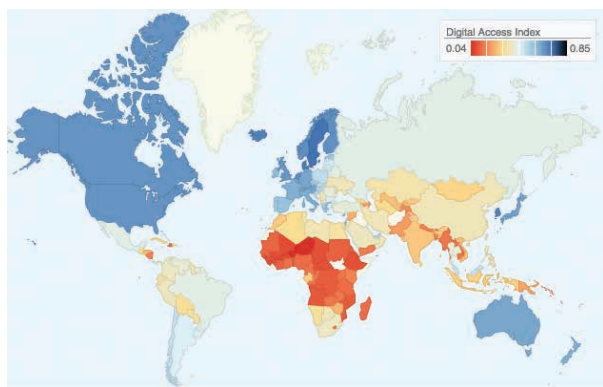
The International Telecommunications Union's (ITU) Digital Access Index (DAI) enables countries to compare themselves to their peers with respect to access to digital technology. The DAI reflects the ability of each country's population to take advantage of Internet communication technologies. It is a composite score of eight variables that measure quality, infrastructure, knowledge, and affordability of digital access (Figure 6.1). It also provides a transparent and globally measurable way of tracking progress toward improving access to ICTs. Through the DAI, the four focus countries chosen for this study can see how they are positioned within the region and in the world with respect to broadband connectivity.

**FIGURE 6.1 Digital Access Index**



Source: ITU, 2012.

**FIGURE 6.2 Digital Access Index**



Source: ITU, 2012.

Figure 6.2 depicts countries' scores on the DAI according to a color-shaded range. The focus countries scored an average of 0.42, where 0 is no access to information and communication technologies (ICTs), and 1 is complete access to ICTs. Peru scored 0.44, and is ranked 83<sup>rd</sup> worldwide, while Argentina and Trinidad and Tobago are the best positioned, scoring 0.53 each. Argentina ranks 54<sup>th</sup> worldwide, while Trinidad and Tobago, in 55<sup>th</sup> place, is better positioned than Mexico (64<sup>th</sup>)

and Brazil (65<sup>th</sup>). Finally, Nicaragua scored a low 0.19 and ranks 135<sup>th</sup> worldwide. According to their scores, Argentina and Trinidad and Tobago are classified as Upper Access Level; Peru as Medium Access Level; and Nicaragua as Low Access Level.

In the LAC region, Argentina and Trinidad and Tobago are surpassed by the Bahamas (0.62, rank 37<sup>th</sup>), Saint Kitts and Nevis (0.60, ranked 39<sup>th</sup>), Chile (0.58, ranked 43<sup>rd</sup>), Antigua and Barbuda (0.57, ranked 44<sup>th</sup>), Barbados (0.57, ranked 45<sup>th</sup>), and Uruguay (0.54, ranked 51<sup>st</sup>). No country in the LAC region qualifies in the Highest Access Level (0.70+), where Sweden (0.85) leads the top, followed by Denmark (0.83) and Iceland (0.82).

### Population Density and GDP

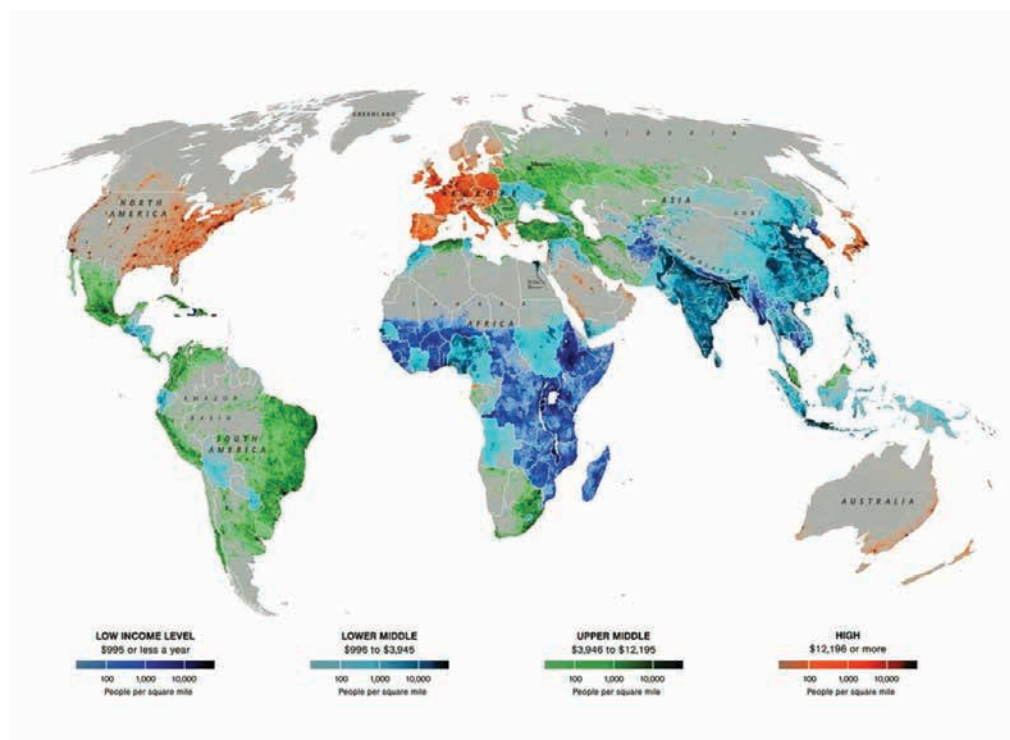
One of the key challenges for government-sponsored digital divide programs is how to deal with the affordability gap. Countries that still do not have broadband access or that are most in need of an increase in broadband access penetration tend to be the least able to afford it, because they are the poorest in terms of per capita gross domestic product (GDP). This is the reason why active government involvement through, for example, universal service obligation policies, is crucial. Such involvement synergistically interacts with the private sector. The LAC region faces another challenge: the affordability gap is larger in rural locations, widening the broadband gap even more.

Figure 6.3 illustrates population density colored by GDP levels. The map shows population density; the brightest points are the highest densities. Each country is colored according to its average annual GDP per capita, using categories established by the World Bank.

Per capita GDP in LAC countries tends to fall within either the upper-middle (US\$3,946–US\$12,195) or the lower-middle (US\$996–US\$3,945) range. Peru and Argentina fall within the upper-middle range, Nicaragua the lower-middle range, and Trinidad and Tobago, the exception, falls within the high (US\$12,196+) per capita GDP range.



**FIGURE 6.3** Population Density and per capita GDP



Source: National Geographic, 2011.

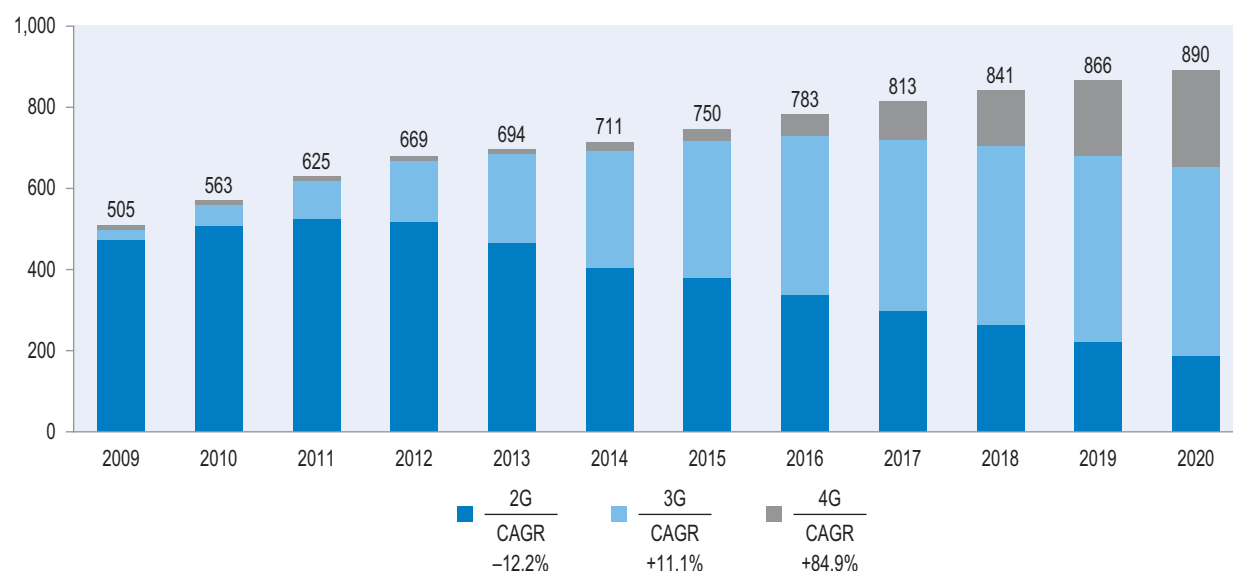
### ***Mobile Broadband in Latin America and the Caribbean: Unique Subscribers and Connections***

Monitoring developments in the cellular broadband transition to 3G and LTE is a key component in bridging the digital divide in the LAC region using satellites. In many instances, it is more cost-effective to leverage satellites as a middle-mile solution to interconnect cellular base station sites in remote, rural, or hard-to-reach underserved areas, or areas not served at all by terrestrial technologies. Such a hybrid satellite-wireless approach can provide technical efficiencies in terms of total cost of ownership (TCO) when compared against (last mile) fixed satellite broadband. It can also bring important commercial and distributional efficiencies derived from the branding power and retail reach of Telcos and mobile network operators, which in most instances are sister companies of Telcos.

This has particular importance for the LAC region, given the widening gap between the penetration of fixed and mobile broadband. Therefore, the potential of satellite-enabled broadband should be assessed in connection with developments taking place in the wireless 3G/4G-LTE broadband.

A study conducted by the GSM Association found that the LAC region is accelerating the take-up of mobile broadband and the growth of data traffic (GSMA, 2014). A rapid technological shift to higher-speed connections that is underway across the region has fueled this acceleration. At the end of 2012, slower 2G services still accounted for 78 percent of total connections, but by September 2014, this had fallen to 60 percent. Correspondingly, 3G connections rose from 22 percent at the end of 2012 to 39 percent by the third quarter of 2014, which is higher than the global average of 32 percent and higher than the developing countries' market average of 27 percent.

**FIGURE 6.4 Total Cellular Connections in Latin America, by Technology Generation**



Source: GSMA, 2014.

By contrast, 4G is still in its infancy, although adoption is expected to accelerate as network launches take place across the region and ongoing deployments in most of the leading markets are completed. As of September 2014, just over 1 percent of connections were 4G, broadly in line with the developing countries' market average but still low compared to 35 percent of connections in North America, the leading LTE market. As shown in Figure 6.4, the number of 4G connections is expected to grow at an average annual rate of 85 percent up to 2020. By then, 2G will still represent over a fifth of all connections.

The LAC region is diverse in terms of economic and social development and in terms of mobile penetration. The GSMA study also found that unique connection penetration rates range from a low of 73 percent in Haiti to a high of 157 percent in Costa Rica. The overall regional penetration rate stood at 112 percent as of September 2014, well ahead of the global average figure of 96 percent.

Subscriber penetration rates in larger markets in Latin America range from a low of 37 percent in Mexico to a high of 77 percent in Costa Rica.<sup>25</sup> There is no single driver of the variation in penetration

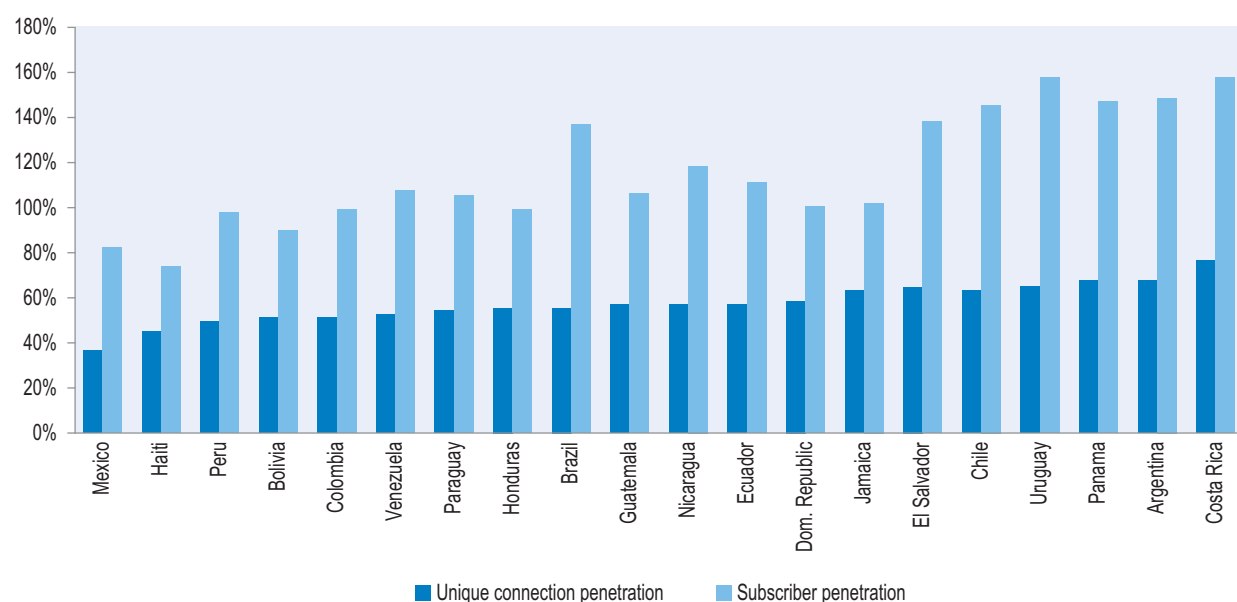
rates; differences in GDP per capita play only a limited role. Figure 6.5 provides an overall picture of mobile broadband penetration for several LAC countries.

### Socioeconomic Summary of the Focus Countries

The following sections provide an in-depth analysis and recommendations for the four focus countries of this study. When reading these sections, it is advisable to refer to the above-listed metrics, as well as Tables 6.1 through 6.4, which benchmark key indicators and differences among the four focus countries.

<sup>25</sup> There is an important difference between the number of mobile connections—the metric traditionally used by the industry to measure market size and penetration—and what is termed unique mobile subscribers. The latter refers to a single individual that has subscribed to a mobile service and that person can hold multiple mobile connections (i.e., SIM cards). If one individual actively uses two SIM connections, that person will be counted by the industry as having two mobile connections, although they are only one mobile subscriber.

**FIGURE 6.5 Mobile Penetration, September 2014**



Source: GSMA, 2014.

**TABLE 6.1 Area, Population, and per capita GDP 2014**

Country	Area (km <sup>2</sup> )	Population	Population density (/km <sup>2</sup> )	GDP (US\$ billion)	Per capita GDP (\$)
Argentina	7,780,400	41,803,125	15	540.19	12,192
Nicaragua	130,375	6,169,269	51	11.8	1,914
Peru	1,285,216	30,769,077	24	202.9	6,594
Trinidad and Tobago	5,130	1,344,235	262	24.43	18,219

Source: World Bank, undated.

**TABLE 6.2 Urban versus Rural Population**

Country	Urban population 2015	Current rural population 2015	Percent urban 2015	Urban population 2025	Projected rural population 2025	Percent urban 2025
Argentina	38,677,436	3,477,478	91.8	42,230,621	3,193,000	93.0
Nicaragua	3,677,533	2,578,977	58.8	4,388,036	2,650,000	62.3
Peru	24,495,382	6,665,785	78.6	28,402,713	6,475,000	81.4
Trinidad and Tobago	113,728	1,232,969	8.4	106,520	1,226,000	8.0

Source: UNDESA, 2014.

**TABLE 6.3 Internet Penetration, 2014**

Country	Internet users	Percent penetration
Argentina	23,543,412	64.7
Peru	11,287,915	40.2
Nicaragua	773,240	17.6
Trinidad and Tobago	729,897	65.1

Source: ITU, 2014.

**TABLE 6.4 Telecom Regulatory Bodies for the Focus Countries**

Telecommunications Regulatory Bodies	
Argentina	Autoridad Federal de las Tecnologías de la Información y las Comunicaciones (AFTIC)
Nicaragua	Instituto Nicaragüense de Telecomunicaciones y Correos (TELCOR)
Peru	Organismo Supervisor de Inversión Privada en Telecomunicaciones (OSIPTEL)
Trinidad and Tobago	Telecommunications Authority of Trinidad and Tobago (TATT)

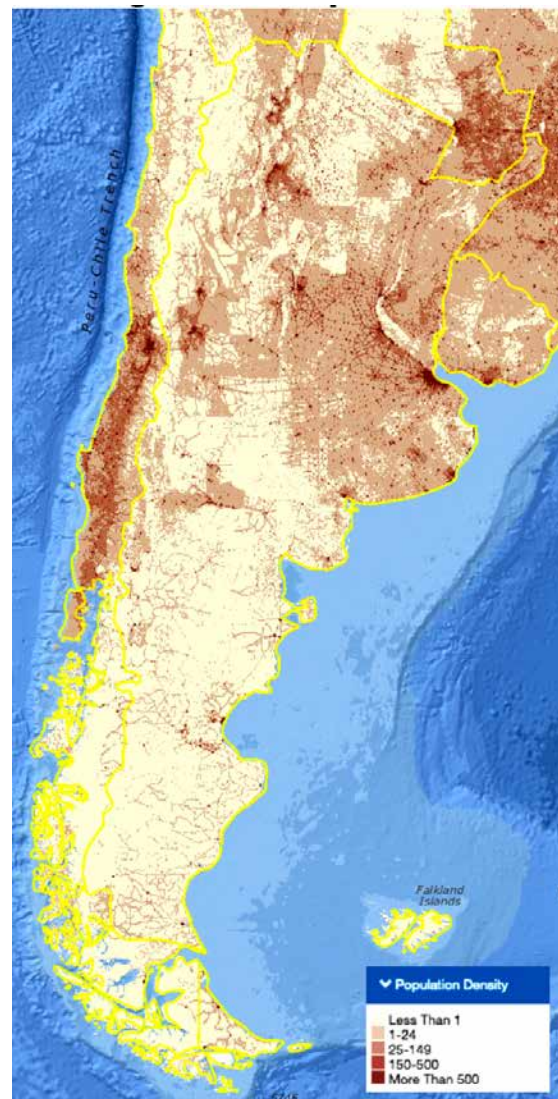
Source: ITU, 2015.

## ARGENTINA

### Geography and Socioeconomic Data

With a mainland area of 2,780,400 km<sup>2</sup> (1,073,500 mi<sup>2</sup>), Argentina is the eighth-largest country in the world, and the second largest in Latin America. Its population is approximately 42 million. Despite its vast and largely habitable territory, it is a highly urbanized country, with 92 percent of the population living in cities. Half the country's population resides in the 10 largest metropolitan areas (Figure 6.6). About 13 million people, roughly one-third of the country's population, live in the Buenos Aires metropolitan area, making Buenos Aires one of the largest urban areas in the world.

The metropolitan areas of Cordoba and Rosario have around 1.3 million inhabitants each.

**FIGURE 6.6 Argentina Population Density Map**

Source: National Geographic, 2015.

Mendoza, San Miguel de Tucuman, La Plata, Mar del Plata, Salta, and Santa Fe each have populations of at least half a million.

Only 3.5 million inhabitants, or 8.2 percent of the population, reside in rural areas. The population density of Argentina is very low and uneven, with vast extensions of its territory having less than one inhabitant per km<sup>2</sup>. This situation presents substantial challenges for justifying economically viable investments in terrestrial telecommunications.

Benefiting from rich natural resources, a literate population, a somewhat diversified industrial base, and an export-oriented agricultural sector, the economy of Argentina is third largest in Latin America, after Brazil and Mexico. It has a very high score on the Human Development Index, and a relatively high per capita GDP. The World Bank classifies Argentina as an upper-middle-income country, with a large internal market and a growing share of the high-tech sector.

Argentina's macroeconomic performance has oscillated between high economic growth and severe recessions. It is characterized by a high concentration of wealth, income maldistribution, and increased poverty. Early in the twentieth century, Argentina had a high per capita GDP and was the third-largest economy in the developing world. By the end of the 1990s, a serious economic crisis emerged, with political and social ramifications. Today, Argentina is considered an emerging market by the FTSE Global Equity Index, and it is one of the G-20 economies. Argentina's population enjoys a relatively high quality of life and per capita GDP.

### *Climate Geography and the Use of Satellite Telecommunications*

The climate of Argentina is mostly temperate and therefore receptive to the use of satellite Ku and Ka-band. The most populated areas are generally temperate. However, the latitudinal spread of the country causes varied climatic conditions, ranging from subtropical to sub-Antarctic. The terrain has rich plains on the northern half, flat rolling plateaus in Patagonia, and rugged Andean mountains along the western border.

Thanks to the concentration of Argentina's population in metropolitan areas, which is advantageous for the provision of broadband services, as well as its relatively high per capita GDP, the country has developed one of the most modern telecommunications infrastructures in Latin America.

Much of Argentina's telecommunications infrastructure is terrestrial. However, Argentina is an important user of satellite-based solutions for key applications, ranging from Ku-band enterprise VSAT and wireless backhaul, to C-band TV distribution

and content origination. Many consider Argentina a pioneer of the shared-hub enterprise VSAT model in the region, where several service providers share common satellite gateway facilities. For example, Impsat (now Level 3) was Hughes's largest client outside the United States in the 1990s. Before the privatization of Intelsat, which took place in 2001–2002, Argentina was ranked among the top 10 Intelsat signatories worldwide in terms of usage of satellite bandwidth for the provisioning of domestic and international satellite services.

### *Telecommunications Environment and Internet Penetration*

The telecommunications sector in Argentina was fully privatized in the early 1990s. This led to substantial foreign investment and development of telecom networks. Today, Argentina has one of the most advanced telecommunications infrastructures in Latin America, with a number of companies in competition and licensed to provide telecom and TV services.

Competition within fixed-line services is attributed to high penetration of cable TV networks. Argentina has the highest cable TV penetration in Latin America. Cable TV companies with modem broadband technology compete against the main telco broadband companies offering ADSL broadband. Coaxial cable networks are widely deployed in urban areas. With over 8 million pay-TV subscribers, and a 65 percent penetration of households, Argentina is the most consolidated market for pay TV in Latin America, representing about 13 percent of the entire Latin American pay TV subscriber base and 14 percent of the pay TV revenue in the entire region.

Argentina's teledensity is the fourth highest in South America after Uruguay, Chile, and Brazil, having been overtaken by the latter in 2012. As in other countries, fixed-to-mobile substitution has adversely affected the Argentine fixed-line market when measured as teledensity. In fact, since peaking at 24.5 percent in 2005, the country's teledensity has been consistently shrinking (Lancaster, 2014). However, market reports about teledensity tend to focus on the use of (copper) telecommunication lines for



fixed telephony services. In Argentina, a number of users that switched from fixed telephony to cellular telephony continue to use coaxial cable for broadband access. Because of a well-developed terrestrial access environment in urban areas, and telco-cable competition, Argentina has a high fixed broadband penetration by regional standards of 64.7 percent.

In most markets worldwide, the mobile market is more competitive than the fixed-line market, and Argentina is no exception. Indeed, the mobile landscape is also quite competitive and evenly distributed. There are three main players: Telefónica's Movistar, Claro, and Telecom Personal, each with a share of about one-third of the market. Despite a well-developed fixed environment, mobile service revenues account for more than two-thirds of total telecom revenues, and this proportion continues to rise at the expense of fixed-line sales.

At the end of 2014, Argentina finalized the auction of 4G spectrum in the 700 MHz band. Movistar (Telefónica) was awarded blocks in the 703-713 MHz and 758-768 MHz range, Personal (Telecom Argentina) secured blocks in the 713-723 MHz and 768-778 MHz range, while Claro (América Móvil) received frequencies in the 723-738 MHz and 778-793 MHz bands (*Telecompaper*, 2015).

In addition, the Ministry of Communications announced that Arlink, an Argentine operator, was assigned frequencies in both the 700 MHz and the Advanced Wireless Services (AWS) spectrum (1.7-2.1 GHz), to provide 3G and 4G services throughout the country. Arlink, owned by the Vila-Manzano group, became a new and important mobile network operator. It is set to alter the mobile market dynamics by potentially becoming a serious contender. The government received a total of US\$2.23 billion for 10 blocks in that auction.

### **Main Telecom Players**

Considering both mobile and fixed-line revenues, Movistar and Personal are the largest telecom operators, followed by Mexico's Claro and Argentina's Grupo Clarín (cable TV and broadband traded as Cablevision and Fibertel) (*BNAmericas*, 2015).

Driven primarily by the growth of broadband services, Movistar and Personal's fixed-line revenues continue to increase. They can be considered the incumbents. The main fixed-line competitors are the multiple cable companies across the country. Some of them are large (e.g., Grupo Clarín). Others are medium-sized or small and are grouped under specific organizations, such as Red InterCable, which aims at empowering small cable companies and cooperatives via terrestrial and satellite infrastructure sharing.

Overall, both the fixed-line and mobile sectors in Argentina enjoy a healthy degree of competition, but this situation cannot be generalized for every town or location across the country. In many smaller cities and towns, competition is limited, since the large players tend to concentrate on major urban areas. Consequently, over the past 10 years, Argentina has been experiencing increasing levels of government intervention, both in terms of strong-handed oversight, tariff regulation, and sanctions, as well as direct intervention via state-managed competition in specific locations and telecom and media sectors.

Thus, while the private sector largely dominates the telecom market, in practice, there is some level of public-private competition on a number of fronts. For example, there is competition between pay TV cable platforms and state-run free digital terrestrial television. The Argentine government is, therefore, a telecom player, via the state-owned company ARSAT (ARSAT, 2015).

ARSAT launched Argentina's first GEO communication satellite (ARSAT-1) and is planning to launch two additional satellites (ARSAT-2 and ARSAT-3). With a combination of Ku-band and C-band payloads, ARSAT-2 is already completed and is being tested for launch later in 2015 (*Telecompaper*, 2015).

In addition, Argentina Conectada, which is Argentina's National Broadband Plan (NBP), is driving an investment of over US\$1.5 billion to bring fiber to remote towns that have limited options and high interconnection fees.

Argentina is expanding the footprint of free, over-the-air digital television, and more than 30



telecom cooperatives have been awarded pay TV licenses. Other aspects where Argentina has shown progress include the country's three top mobile operators, which launched handsets with built-in free digital terrestrial TV reception (similar to Japan's "OneSeg" mobile TV with less acceptance) and a decree passed to regulate Mobile Virtual Network Operators.<sup>26</sup>

### **Telefónica de Argentina S.A.**

Telefónica de Argentina provides local and international fixed telephony services, as well as retail broadband Internet access under the brand Speedy. It also operates telecontrol and commercial call centers (*telecentros*). The firm was one of two telcos spun off from the former state telecommunications company, Entel, in 1990. The company enjoyed exclusivity in the local loop until full market deregulation in 2000. Currently, it has about 30 percent of the market. Spanish telecom giant Telefónica fully controls Telefónica de Argentina.

### **Telecom Argentina S.A.**

Telecom Argentina is an Argentine telco that owns licenses to provide fixed-line, mobile, public telephony, Internet, and local, long-distance, and international telephony services. In the mobile market, Telecom Argentina operates in Paraguay under its subsidiary Nucleo S.A. It operates in both countries under the commercial brand name Personal, which also offers 4G/LTE services in spots of Buenos Aires, Cordoba, and Rosario.

Although it is based in Buenos Aires, the company is indirectly controlled by Telecom Italia, which, in 2013, agreed to sell its controlling stake in Sofora Telecomunicaciones to U.S. investment fund Fintech. Sofora is the holding company that controls Telecom Argentina through its subsidiary Nortel. As the transaction has failed to win regulatory approval, both firms have agreed to three deadline extensions to close the deal. In mid-2015, Telecom Italia's largest investor won approval from Argentina's competition regulator to unravel an eight-year holding pact,

clearing the way for Vivendi S.A. to take a stake in the Italian carrier (Lepido, 2015).

### **Claro Argentina S.A.**

Mexican América Móvil fully controls Argentine telecom operator Claro Argentina. Under the Claro brand, the Mexican telco offers mobile, fixed, and long-distance services. The company provides 3G coverage to a large number of municipalities across the country. Claro Argentina started as a mobile telephony operator in 1994 and is based in Buenos Aires. In late 2014, the firm became the first company to be officially awarded additional 3G and 4G/LTE spectrum in Argentina. At the time of this report, Claro has commenced operations of its 4G network.

### **FiberTel S.A. / Cablevision S.A.**

The Clarín Group-owned cable TV operator Cablevision provides a range of cable products and related services, such as cable TV and high-speed Internet via its brand Fibertel in Buenos Aires and other regions of Argentina. The company is the first cable operator in South America to deploy a 100 gigabit per second optical network to boost multicast video services and high-speed Internet access. In 1997, the company formed a subsidiary, Fibertel, to offer unlimited Internet access to its clients, but it ceased operations in 2002. Cablevision also has a presence in Uruguay, where it offers cable TV services in Montevideo and Canelones through its subsidiary, Telemas. In 2013, the firm sold its Paraguayan operation to Tigo, the local unit of Luxembourg-based Millicom International Cellular S.A., a global telecommunications group.

<sup>26</sup> See Decree 2.426/2012, enacted on 13 December 2012, available at <http://www.infoleg.gob.ar/infolegInternet/anexos/205000-209999/206135/norma.htm>. Article 4 of Decree 2.426/2012 incorporates into Annex I of Decree 764/2000, the Article 8 bis, which establishes: "[t]hose interested in providing mobile phone services, which do not hold assigned radio spectrum for the provision of these services, must hold a telecommunications services license, and a registration as a virtual mobile operator."

Cablevision was founded in 1981 and is based in Buenos Aires.

### **ARSAT (Empresa Argentina de Soluciones Satelitales S.A.)**

The Empresa Argentina de Soluciones Satelitales (ARSAT) is an Argentine state-run satellite and general telecommunications firm. Among other assets, it holds exclusive rights to operate and commercialize geostationary orbital position 81W in Ku-band (North and South America) and C-band (hemispheric coverage). ARSAT acts as both a satellite operator and as a reseller of satellite capacity to third parties. It is also in charge of the development of satellite and terrestrial infrastructure for the state's digital TV system.

ARSAT's teleport facilities, located on the outskirts of Buenos Aires, serve seven satellites covering the entire southern Latin American area, delivering satellite bandwidth for voice, data, audio, and video services. Founded in 2006 and based in Buenos Aires, ARSAT is tasked with the implementation of Argentina's national connectivity plan. In that context, the firm launched its first geo-stationary satellite, ARSAT-1, in 2014, aiming to strengthen the country's Internet coverage and DTH network, and improve audio-visual content distribution from Argentina to the rest of Latin America and the United States, by a reciprocity agreement.

Argentina has the rights to geostationary orbital locations at 72 degrees west and at 82 degrees west. Additionally, ARSAT has constructed a large datacenter facility co-located with its main satellite teleport. This can become useful for hosting third-party application servers and as a platform for the virtualization of teleport functions.

#### ***Policy and Regulation***

In December 2014, a new regulatory body, the Federal Authority of Information and Communication Technologies (Autoridad Federal de las Tecnologías de la Información y las Comunicaciones, or AFTIC) (Ley Argentina Digital, 2014), was created to

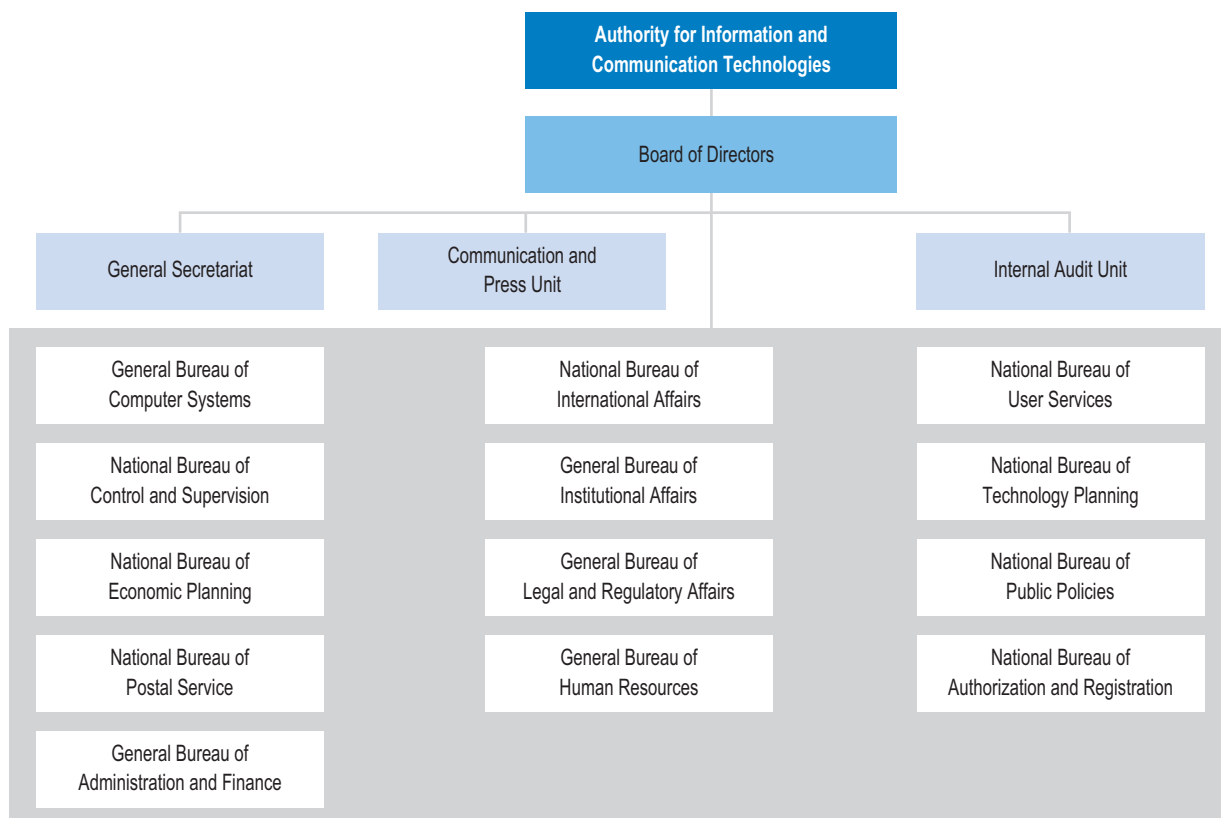
replace the Secretary of Communications (SeCom) and the National Communications Commission (CNC), potentially leading to a radical overhaul of the telecom sector in the long term. Moreover, the law creating AFTIC enables telecom operators to offer bundled services including TV, which is a long-pending regulatory change for Argentina. Starting in April 2015, AFTIC's composition was determined through several decrees (AFTIC, 2015). Figure 6.7 depicts AFTIC's organizational chart.

In addition to replacing a number of existing bodies, including SeCom and the National CNC, AFTIC will incorporate the Argentina Contectada plan, the various companies under the ARSAT umbrella, and Correo Argentina, the state-owned postal service.

Argentina's economic outlook for 2015 revolved around a stagnant economy and high inflation, which represented a serious problem for the country. However, at the end of 2015, a more open and business-friendly administration was elected, and there are expectations for an economic rebound in 2017. The fastest-growing telecom service in 2015 was the mobile telephone data service. Following the recent spectrum auction and new spectrum awards addressed earlier, the LTE sector seems to be set for further development and growth. While there is a high degree of confusion and public-private friction as a result of the participation of state-owned ARSAT in the market, it could be argued that Argentina's regulatory framework encourages competition and supports smaller telecom players, such as cooperatives in medium and smaller towns. Like Peru, Argentina also adopted a single license (*licencia única*), which telecom companies must obtain regardless of the services they wish to provide. Operators must list in their license applications which services they wish to offer, but they can register for additional ones at any time. However, the wholesale market is poorly regulated, and this seems to be the key battleground for the expansion of broadband access.

In other regulatory aspects, Argentina has been delaying reforms, limiting further advancements and cross-platform competition. For example, with a few exceptions, cable TV companies cannot yet offer telephony services, and telcos cannot offer

**FIGURE 6.7 AFTIC's Organizational Chart**



Source: AFTIC, 2015.

Internet-based TV services, although in practice, bundled services are offered via telco-DTH partnerships. Another unique regulatory constraint in Argentina has to do with satellite TV. DirecTV is the only pay TV (DTH satellite) operator licensed to operate a satellite pay TV platform in the country.

### **National Broadband Plan**

Concerning government-sponsored programs aimed at bridging the digital divide and urban-rural gap, Argentina has developed several programs over the past 20 years, generally with limited impact. Thus, there have been no consistent programs to bridge the digital divide for rural areas with accessible, consumer-grade satellite services, although the country makes extensive use of satellite wireless backhaul.

The Argentina Conectada plan, introduced in October 2010, tried to integrate several ICT

initiatives, such as the implementation of digital terrestrial TV and the introduction of notebooks in colleges, as well as responding to the regional imbalance in access to high-speed networks. The plan was to widen coverage and improve the quality of broadband Internet access service, particularly in areas that are not profitable for private operators.

One of the central themes of the plan has been the deployment of a Federal Fiber Optic Network. The area of the network is estimated at approximately 50,000 km, including:

- The building of 22,000 km of provincial networks, and 18,000 km of inter-provincial network
- The use of existing dark (unused) fiber stretches owned by the electric company Transener (in which the State is a shareholder)
- Fiber exchange agreements with several private operators

It was hoped that the backbone would cover 97 percent of the population by 2015, with local operators responsible for providing service in the last mile. Not surprisingly, despite progress, anticipated delays in the plan have indeed materialized. However, as of July 2015, it was not clear how much of the original plan has been accomplished.

As an extension of the State in all aspects related to telecommunication initiatives, the operation of the Federal Fiber Optic Network was assigned to ARSAT. While the government plan emphasizes the need to reduce costs and increase competition in the wholesale access market, a structural separation of the new state operator from oversight functions was not established, enabling ARSAT to enter the retail market. This direct government competition with the private sector at the retail level makes an important difference with countries like Peru, which has adopted clearly defined rules. Nevertheless, Argentina's strategy shows several similarities with that of Brazil, which has adopted a similar approach with its state-owned Telebras. Telebras manages fiber deployment and will operate the state-owned SGDC<sup>27</sup> communication satellites.

Following the trend of combining modern digital divide programs with social policy, the Argentina Conectada plan also considers several initiatives that complement the deployment of the fiber network. For example, the plan promotes the creation of public access and training centers (called Access to Knowledge Units and Digital Access Points), as well as digital literacy initiatives, and supports research in communication technology.

It is still unclear if AFTIC will continue with the original Argentina Conectada plan, or begin implementing Argentina's Digital Law, forcing a complete rethinking of the program. Moreover, given the country's slowing economy, it is not known how long it will take the newly created AFTIC regulator to carry out the objectives in the Argentina Digital Law, including the objective of "complete neutrality of networks"<sup>28</sup> to "enable access by all Argentines to information and communications services in equitable social and geographical conditions."<sup>29</sup>

The initiative aims to bolster competition among service companies, so that small companies or cooperatives can provide Internet services to every household in the country, using infrastructure owned by other companies. The goal is to enable customers to choose a service provider regardless of infrastructure ownership. The Argentina Digital Law also embodies the principle that ICTs are essential for socioeconomic development, and that access should be guaranteed to all regardless of geographic area or socioeconomic status.

Moreover, the Law calls for restructuring the services according to the concept of "universal service," standardizing tariffs and quality across the country and defining ICT as a "competitive public service." These objectives require regulation that covers the whole range of services, from backbone networks to retail access, defined as "last mile" or "local loop."

Consequently, telecom operators will be required to provide access and interconnection to other operators. AFTIC must first approve any use of shared infrastructure. Some operators that have a dominant role in the provision of residential services will have to be disaggregated in the local network, or to open their network to others (that is, local loop unbundling). Nevertheless, although the objectives are clear, the exact negotiation mechanisms between the dominant incumbents and incoming carriers are not yet fully defined or regulated.

### *Funding*

Argentina's Universal Service Trust Fund (USTF) was created by Decree 764 in 2000.<sup>30</sup> The USTF

<sup>27</sup> SGDC is a national satellite program that addresses communications needs of the Federal Government, including the National Broadband Program (PNBL), and strategic/defense communications.

<sup>28</sup> See Law 27.078, supra note 22, Article 1. Available at [http://www.aftic.gob.ar/multimedia/noticias/archivos/201506/archivo\\_20150611022151\\_7221.pdf](http://www.aftic.gob.ar/multimedia/noticias/archivos/201506/archivo_20150611022151_7221.pdf).

<sup>29</sup> Ibid.

<sup>30</sup> See Decree 764/2000, enacted on 3 September 2000, Article 14.2, available at <http://infoleg.mecon.gov.ar/infolegInternet/anexos/60000-64999/64222/norma.htm>.

requires a 1 percent contribution from licensed telecommunications companies' revenues.<sup>31</sup> The trust fund was established to allocate funds to a specific set of projects that met pre-established goals. While the fund is still accumulating money, it appears to have been only used for e-education at schools.

On a regulatory level, the original Argentina Conectada plan considered distinct initiatives to encourage competition, such as the tender of new radio spectrum for mobile broadband networks (LTE spectrum was licensed in 2014), and the reactivation of the universal service fund. This is accompanied by support through credit and technical assistance for cooperatives and small private broadband service operators, which are considered essential to achieve the coverage and implementation objectives defined.

For a 2011 to 2015 five-year plan, a total investment was originally estimated at 8 billion Argentine pesos (approximately US\$1.8 billion), with almost one-half allocated to the fiber backbone. To date, it is unclear how much money has been spent and how much of the original plan has been actually accomplished. However, tenders have been issued for the building of multiple stretches (over 18,000 km) of the federal fiber network, in addition to the construction of the national data center managed by ARSAT.

Shared access and training centers have been inaugurated in several provinces, and there has been progress in cooperation agreements for the creation of traffic exchange points with neighboring countries, particularly Brazil and Uruguay. Considering the similarities between the ARSAT-managed projects in Argentina and the Telebras-managed initiatives in Brazil, it is expected that the respective fiber networks of Brazil and Argentina will eventually fully connect.

### **Satellite Operation and Acquisition**

Argentina has been a historically important user of satellite capacity provided by global and regional satellite operators, including Intelsat, SES, Satmex (now Eutelsat Americas), and others. However, with the creation of the state-owned national satellite operator ARSAT, and the launch of its first

communication satellite fully developed and integrated in Argentina, the country has been gradually ignored by major global operators when planning future satellite payloads. As an example, the third of the Intelsat Epic<sup>NG</sup> series of satellites (IS-35e at the 325 degrees East orbital slot), to be launched in 2017, will provide substantial C-band spot beam capacity for Latin America, but coverage maps published by Intelsat do not show beams over the Argentine territory. This seems clearly to relate to the direct and dominant participation of ARSAT in the Argentine markets and to its increasing role in the country's domestic satellite communication business.

Argentina has a very sophisticated high-tech sector by regional standards, due to its own satellite program and fourth-generation nuclear power station designs through state-owned INVAP. Argentina has a comprehensive and ambitious satellite research and development program, which includes communication satellites as well as earth observation, micro satellites, and even launch services for LEO observation satellites. Space research has become increasingly active in Argentina. Aside from the ARSAT satellite, Argentine-built satellites include LUSAT-1 (1990), Victor-1 (1996), PEHUENSAT-1 (2007) and those developed by CONAE, the Argentine space agency, of the SAC series.

### **Proposed Solutions**

It is important for Argentina to develop more "market-friendly" policies and attract foreign investments. Argentina could then return to international markets, with global and regional satellite operators benefitting from an upward demand trend for satellite capacity.

Nevertheless, even with strong government intervention through the state-owned ARSAT system, Argentina will never be completely left out of the international satellite markets. ARSAT's satellite business is primarily in Ku-band, limiting its usefulness on a LAC regional level. While a potential future provision of Ka-band capacity with the ARSAT-3

<sup>31</sup> Ibid, Article 19.



satellite or subsequent satellites is certainly possible, Argentina continues to play a strong role in the market of C-band video distribution and content origination, which intrinsically targets a regional marketplace. Large content providers such as Turner and Disney uplink TV signals from Argentina for the Latin America Spanish-speaking pay TV community, requiring the use of international satellite operators offering C-band coverage of the hemisphere.

Moreover, Argentina is a very pragmatic country, which can take drastic regulatory measures in terms of policies, with inevitable implications for the private sector. Nevertheless, it would be a mistake for Argentina to ignore developments in satellite research and development taking place internationally. Consequently, ARSAT will likely continue to be an important satellite player in Argentina, but political and socioeconomic shifts could modulate its gatekeeping functions.

To summarize, it is difficult to predict accurately the success of future policy-changing events in Argentina and their importance for satellite communications. However, considering the overall status of the telecommunications market, the new law, government broadband programs and initiatives, and the role of ARSAT, the key recommendation for either financing or empowering the expansion of satellite broadband programs in Argentina is to proceed in close coordination with the Argentine government, and with AFTIC and ARSAT in particular. There is a possibility that ARSAT will attempt to leverage Ka-band spot beam connectivity for satellite broadband in the future. An architecture mixing Ka-band spot beams with Ku-band and Ka-band wide beams (similar to the Australian NBN Co.) is a model to explore.

Unlike in countries such as Brazil and Peru, the use of satellites for wireless backhaul is not as prevalent in Argentina given the population density and territory considerations. Nevertheless, the need for satellite connectivity for this application will remain. Therefore, Argentina can use a combination of capacity provided by international satellite operators and by ARSAT, using either C-band or Ku-band capacity to connect cell sites economically to the wider national networks.

## SUMMARY AND KEY RECOMMENDATIONS FOR ARGENTINA

Although Argentina has a well-developed telecommunications infrastructure, it certainly has gaps to fill. Its vast territory, coupled with a highly concentrated population in a few spots, acts as a deterrent for the expansion of terrestrial networks to areas across the country with low population densities. Satellites' distance insensitiveness can be leveraged to bring both wireless broadband and fixed broadband access to such remote areas.

Fortunately, the Argentine government is actively involved in bridging the digital divide through a set of programs involving the use of both satellite-based and fiber infrastructure. The role of ARSAT is especially important, particularly in relation to the Argentina Conectada national broadband plan. The alternative to relying on a state-owned company to bridge the digital divide is that specific projects can be at odds with the private sector's profitability interests and may not necessarily strike a good balance between public and state-funded projects.

It is highly recommended that Argentina continues leveraging its state-owned and operated telecom resources, but in ways that can interplay more synergistically with the private sector. Argentina has enormous opportunities to leverage its domestic R&D resources (including domestically developed communication satellites) to develop a comprehensive infrastructure that, rather than competing at times with the private sector, can be leveraged as a true enabler and catalyst for innovation and network expansion. Key recommendations for Argentina include the following (see also Box 6.1):

- Continue leveraging the ARSAT fiber and satellite programs, but seek more collaboration with the private sector. Implementing such programs as "open access" wholesale networks that empower innovation and retail network expansion through a public-private partnership is highly advisable.



- Project clear signs of additional openness to foreign investment in the area of satellite communications to limit the impact of the strong ARSAT play.
  - Future coverage plans by international satellite operators indicate that they have started ignoring Argentina due to the satellite regulatory barriers and strong ARSAT play. This situation is not desirable.
  - Issuing satellite landing rights more promptly, even if foreign satellites could potentially compete with the ARSAT satellites, is important for a fluid and more competitive satellite environment that can ultimately lower the cost of bandwidth.
- Leverage Ka-band multi-spot beam architecture for broadband expansion. Future generations of ARSAT satellites with a combination of wide beam and spot beam capacity can take full advantage of Ku and Ka-bands to bring broadband access and wireless backhaul cost-effectively to remote areas. The Brazilian SGDC and the Australian NBN Co. programs are good examples of what ARSAT could accomplish for Argentina.
- Conduct a more strategic and detailed study of the future role of ARSAT and Argentina's hybrid broadband infrastructure as an open-access telecommunications leveler and catalyst for the expansion of broadband access.
  - Argentina has great resources and prospects for a more cooperative and empowering future telecommunications environment via a public-private partnership.
  - Study the retail role that a vast array of small, rural cooperatives can play in regards to leveraging a wholesale, empowering state-run infrastructure with shared resources and virtualized functions.
- In the context of an open-access framework, key elements to analyze in further studies are the innovation and development virtues that could be extracted from ARSAT's satellites and ground network resources when used in combination with the recently built datacenter facility. With the advent of high-throughput satellites, satellite networks are transitioning toward leveraging virtualization functions for the provisioning and operation of networks and applications. The ARSAT datacenter is reported to be the only one in the country that received Tier-3 classification, assuring high service standards. It could thus be leveraged to connect local and regional networks reliably with the global telecom cloud.

### Box 6.1 Argentina: Upper Access Level

Argentina has one of the most advanced telecommunications infrastructures in Latin America. The country is an important user of satellite-based solutions for key applications, ranging from Ku-band VSAT and wireless backhaul to C-band TV distribution and content origination. At the end of 2014, it finalized the bid for the 4G spectrum. A single authorization is needed to provide broadband services. The regulatory agency is AFTIC and the main telecom operators are Movistar, Personal, Claro, Cablevision, and Fibertel. State-owned ARSAT participates in the market. The wholesale market is still poorly regulated and reforms have been delayed, limiting further advancements and cross-platform competition. Argentina has a funding program, the Universal Services Trust Fund (USTF), to which licensed telecommunications companies contribute 1 percent of their revenues. Key recommendations for Argentina include the following:

- Establish an environment where state-owned and operated telecom resources can interplay with synergy with the private sector
- Project clear signs of additional openness to foreign investment in the area of satellite communications
- Leverage Ka-band multi-spot beam architecture for the broadband expansion and resolve any administrative task still pending within AFTIC.

Finally, the recent reorganization of Argentina's legal and regulatory framework in relation to broadband and the establishment of AFTIC left a number of detailed administrative tasks unresolved. Considering that the Argentine government is an active telecommunications operator through ARSAT, it is highly recommended that the remaining organizational tasks be completed in a speedy and transparent way in order to achieve a stable and easily understood policy and regulatory foundation. Ultimately, a regulatory bias that favors government financial interests to the detriment of the private sector must be avoided.

## REPUBLIC OF NICARAGUA

### *Geography and Socioeconomic Data*

Nicaragua is the largest and the least densely populated country in Central America. It covers a total area of 130,375 km<sup>2</sup> (119,990 km<sup>2</sup> of which is land area), roughly the size of Greece or the state of New York. Approximately 41 percent, or 2.5 million, of its 6.2 million inhabitants live in rural areas.

Nicaragua has a variety of climates and terrains: the Pacific lowlands, the humid and cooler central highlands, and the hot, humid Caribbean lowlands. The most populous city in Nicaragua is the capital, Managua, with a population of more than 2.5 million.

Nicaragua ranks among the poorest countries in the Americas. Its 2014 GDP was approximately US\$11.8 billion. Agriculture represents 17 percent of the country's GDP, the highest percentage in Central America. Remittances account for over 15 percent of GDP. Despite these numbers, Nicaragua has been experiencing robust economic growth. In 2014, the economy grew at 4.2 percent, and the five-year average annual growth rate was 3.2 percent.

However, the country's significant GDP growth since 2010 started from a low economic base: Nicaragua has the lowest per capita GDP in the Latin America region (US\$1,914). As a result, Nicaragua's economy has benefited from international

assistance, particularly from the World Bank, the IDB, and bilateral agencies.

According to the World Bank's *Doing Business Report*, Nicaragua ranked the 123<sup>rd</sup> economy for starting a business. Nicaragua's economic freedom score is 57.6 with high levels of fiscal, government, labor, investment, financial, and trade freedom. It ranks as the 108<sup>th</sup> freest economy, and 18<sup>th</sup> (of 29) in the Americas (World Bank, 2015). However, international assistance and pro-market policies have not yet fully translated into sustainable socio-economic development. According to the United Nations Development Programme (UNDP) 42.5 percent of the population of Nicaragua lives below the poverty line (UNDP, 2009).

Nicaragua is primarily an agricultural country, with agricultural products constituting 60 percent of total exports. Its minimum wage is among the lowest in the Americas and in the world. Rural workers depend on agricultural wage labor, especially in coffee and cotton. Only a small fraction hold permanent jobs, while most are seasonal migrant workers who harvest crops during the harvest period and seek other work during the off-season.

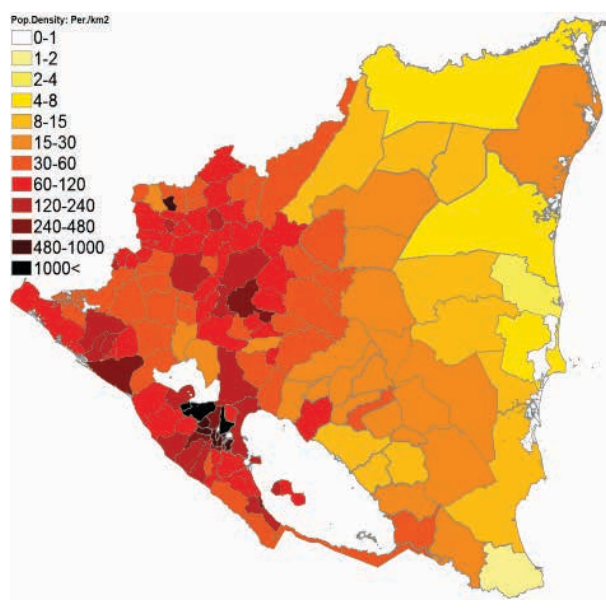
The urban poor participate in the informal sector of the economy. The informal sector consists of small-scale enterprises that use traditional technologies and operate outside the legal regime of labor protections and taxation. Workers in the informal sector are often self-employed, unpaid family workers, or employees of small enterprises.

There are efforts underway to build a canal between the Pacific and Caribbean, largely with Chinese funding. This canal would will incorporate deep-water ports, an oil pipeline, railroads, and an international airport. It is an ambitious attempt to achieve greater long-term economic benefits, although the feasibility of the project and its timeline remain uncertain.

### *Climate Geography and the Use of Satellite Telecommunications*

Temperatures do not vary significantly with the seasons in Nicaragua; rather, they are largely a

**FIGURE 6.8** Map of Nicaragua's Population Density



Source: TELCOR, 2015.

function of elevation. The “hot land” is characteristic of the foothills and lowlands from sea level to about 750 meters (2,461 ft.) above sea level.

With respect to satellites, Nicaragua can be served by satellite systems using any of the frequency bands (C, Ku, or Ka). Even for small countries like Nicaragua, frequency bands can have varying levels of performance and cost-effectiveness because of greatly varying rainfall statistics. The Caribbean lowlands are the wettest section of Central America, receiving between 2,500 and 6,500 millimeters (98.4 and 255.9 in) of rain annually. The western slopes of the central highlands and the Pacific lowlands receive considerably less annual rainfall, as the peaks of the central highlands protect them from moisture-laden Caribbean tradewinds.

### **Telecommunications Environment and Internet Penetration**

Nicaragua's telecom market is undeveloped. It has the lowest fixed-line teledensity and mobile penetration of any country in Central America. The

broadband market remains in an incipient stage; only 17.6 percent of the population have access to broadband, which is considerably lower than the average for Latin America. Most Internet users are concentrated in the largest cities, because rural areas lack the most basic telecom infrastructure. A number of Internet cafes provide public access to Internet and email services, but these are mainly located in the larger population centers.

### **Main Telecom Players**

América Móvil's Claro is the leading incumbent telecom company in Nicaragua's telecom sectors, including fixed-line, mobile, broadband, and pay TV. Mobile subscriber numbers overtook the country's main lines in early 2002 and now make up a significant majority of all lines.

Telefónica's Movistar is the only company competing with Claro in the fixed-line and mobile market. Movistar has almost one-third of the mobile market but only 10 percent of the country's fixed lines in service. Because of Nicaragua's underdeveloped regulatory structure and bureaucratic delays, further liberalization has been slow. The dominant situation of these two telecom companies has slowed the competitive drive; as a result, Nicaragua has made less of an effort than neighboring countries to improve quality of service and lower prices. Other companies operating in the market include the Russian state corporation Rostejnologuii, Yota Mobile, and IWB Holding, which are seeking to obtain a larger share of the broadband market.

The fixed-line market will probably continue to be slow moving but stable, while growth will occur mainly in the mobile and broadband sectors. Competition in the mobile sector is expected to improve with the introduction of Xinwei, a new, China-based operator, following the auction of spectrum in the 1800MHz band. The mobile broadband sector will be the main growth engine, given the extremely low penetration rate and the growing consumer demand for mobile services. In this regard, assuming that

economic growth continues, the longer-term prospect is promising.

Analysts say that Xinwei's arrival has damaged the dominance of Telefónica's Movistar and América Móvil's Claro. Xinwei, in the meantime, is rolling out more advanced 4G networks, offering superior broadband service at far cheaper prices. Analysts expect a high demand for wireless Internet service in Nicaragua because of the country's rugged terrain and sparse population density.

### **Empresa Nicaragüense de Telecomunicaciones S.A. (Claro)**

Empresa Nicaragüense de Telecomunicaciones (Enitel), operating under the brand name Claro, is a subsidiary of Mexico's América Móvil. The company provides fixed, mobile, and other telecommunications services in Nicaragua. The company is based in Managua, Nicaragua.

### **Telefonía Celular de Nicaragua S.A. (Telefónica Movistar)**

Telefonía Celular, the Nicaraguan unit of Spanish telecom giant Telefónica, is a mobile telecommunication services provider. It operates under the brand name Movistar. It launched operations in Nicaragua in September 2004, taking over a client base formerly managed by BellSouth. Movistar offers voice services, enhanced calling features, international roaming, wireless Internet and data services, wireless intranets, and other corporate services. Telefonía Celular is based in Managua.

### **Yota de Nicaragua**

Yota de Nicaragua is a unit of Yota Mobile WiMax, which is a subsidiary of the Russian state corporation Rostejnologuii. Yota, a Russian-Venezuelan-Nicaraguan consortium, won a bid in 2009 for a fixed wireless and Internet concession in Nicaragua in the 2,500–2,690 MHz bands.

### ***Policy and Regulation***

The Nicaraguan Institute for Telecommunications and Posts (TELCOR) is the regulator of telecommunications and postal services. TELCOR is responsible for developing norms, regulations, technical planning, monitoring and implementation, and enforcement of laws and regulations governing the installation, interconnection, operation, and provision of telecommunications and postal services. TELCOR also manages and regulates the radio frequency spectrum. It grants concessions, licenses, permits, or certificates of registration to companies interested in providing telecommunications and postal services or in using the frequency spectrum.

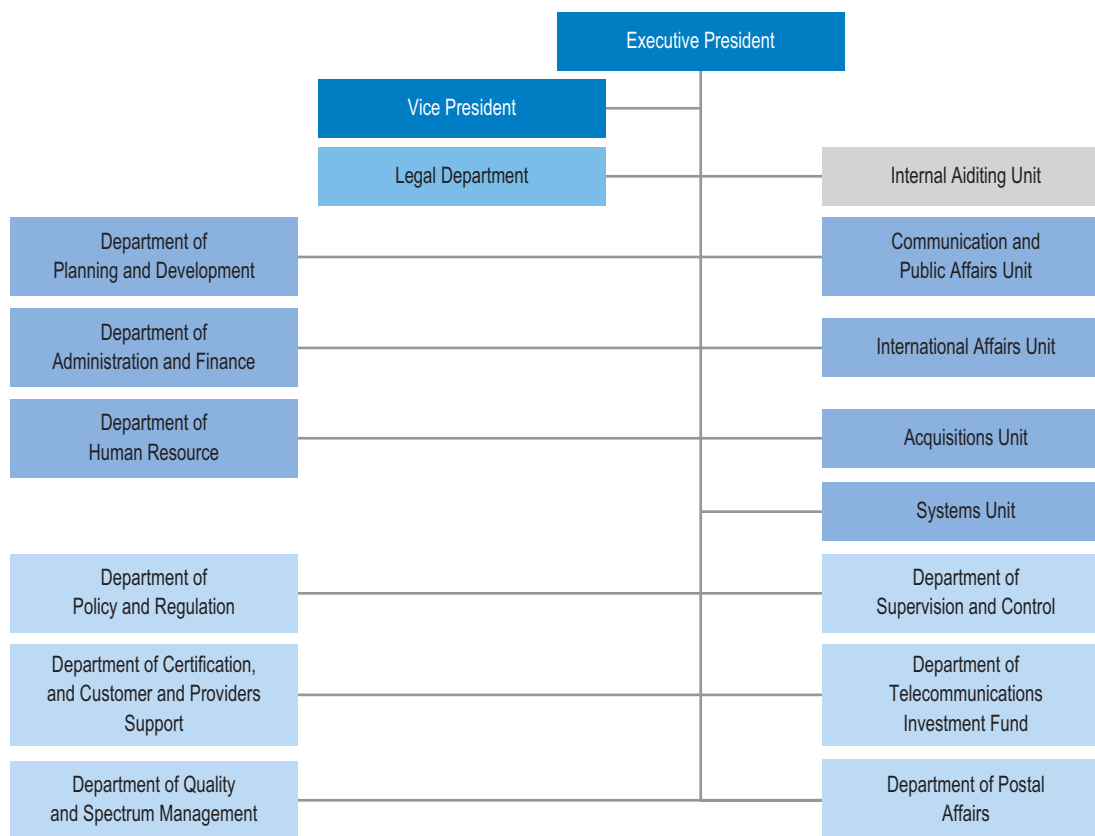
### ***National Broadband Plan and Funding***

While Nicaragua defined a universal service obligation fund, it does not have a national broadband plan. Decree No. 84/2003 created the Telecommunications Investment Fund (FITEL) exclusively to finance the provision of telecommunications services and information technology for rural and low-income locations, to ensure universal access to all inhabitants of the country.<sup>32</sup> TELCOR is responsible for the administration of FITEL. It is governed independently, with financial autonomy and separate accounts.

Within the organizational structure of TELCOR (Figure 6.9), FITEL is in charge of the design and implementation targeted actions to ensure the provision of telecommunications services and information technology in rural areas, and efficient use of the FITEL resources (Figure 6.10).

<sup>32</sup> See Decree No. 84/2003, Creation of the Telecommunications Investment Fund (FITEL). Available at [http://www.telcor.gob.ni/MarcoLegal.asp?Accion=VerRecurso&REC\\_ID=194](http://www.telcor.gob.ni/MarcoLegal.asp?Accion=VerRecurso&REC_ID=194). Later, it was enacted Decree No. 5/2006, Constitution of the Telecommunications Investment Fund, FITEL. Available at [http://www.telcor.gob.ni/MarcoLegal.asp?Accion=VerRecurso&REC\\_ID=406](http://www.telcor.gob.ni/MarcoLegal.asp?Accion=VerRecurso&REC_ID=406).

**FIGURE 6.9 TELCOR's Organizational Chart**



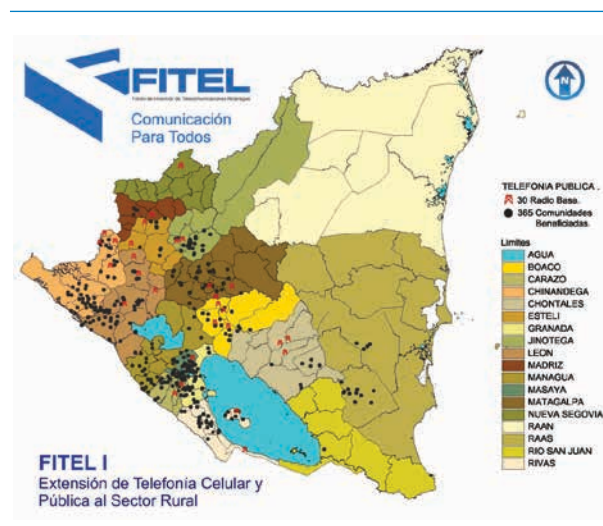
Source: TELCOR, 2015.

### Satellite Operation and Acquisition

Nicaragua leases satellite capacity via the open international markets of regional and global satellite operators with coverage over its territory. Nevertheless, Nicaragua has plans to launch its own satellite, NicaSat-1, to support its telecom sector. Once the satellite is launched and placed in orbit, which is planned for late 2016 or early 2017, Nicaragua plans to leverage this asset to enhance cellular telephony, Internet access, and pay TV services across the country. Satellite coverage maps have not yet been released to the public.

In 2012, the Nicaraguan government announced the acquisition of a GEO telecommunications satellite from China, with an investment of around US\$250 million. While the details of the

**FIGURE 6.10 FITEL—Coverage Areas for Fixed Lines and Mobile Stations**



Source: FITEL, 2015.



deal are unknown, it is expected that it is similar to TKSAT-1. Also launched through an agreement with China, TKSAT-1 is currently operating successfully in Bolivia, with a high fill rate. It is possible that Nicaragua enjoyed favorable pricing conditions regarding the satellite acquisition because of China's strong interest in cooperating with Nicaragua to improve its telecom infrastructure. China's interest is particularly relevant in the context of the export of natural resources and the proposed interoceanic canal that, if built, would be largely funded by China. However, the cost concerns for domestic satellite systems should be taken into consideration.

### *Proposed Solutions*

Given the state of the telecom industry in Nicaragua, its low economic development, and low broadband penetration, it is clear that the country needs to move toward developing and implementing efficient and socially integrated policies. It also needs to cooperate with the private sector to quickly modernize the country's telecom infrastructure and gradually bridge the digital divide. Nicaragua could greatly benefit from the flexibility and distance-independent costs of satellite communications.

Without knowing the details of the agreement between Nicaragua and China for the development of a national satellite, it is not possible to calculate its potential economic effectiveness when benchmarked against the alternative of leasing satellite capacity in the open international satellite market or entering into a hosted payload arrangement with one of the large satellite operators.

Nevertheless, despite the needs for satellite-based communications, Nicaragua is not a country that would have been expected to pursue an ambitious domestic satellite program on its own because of its size and addressable market. The business of satellite operation tends to benefit from economies of scale. Consequently, it is likely that relying on existing solutions would be more cost-effective. Nonetheless, and

assuming that Nicaragua will launch the satellite in 2016 or 2017, this report offers the following recommendations:

- Nicaragua should leverage its own satellite resources as much as possible and for as many applications as possible, including wireless backhaul, DTH, and residential or enterprise VSAT, to name a few key applications.
- Nicaragua should consider the use of satellite spot beams that can increase the cost-effectiveness of the links and maximize the amount of bits carried per unit of spectrum (Hertz). If the satellite is still in the design phase, it should also consider using some capacity for wide-beam coverage of neighboring countries as a hedge strategy, and it should develop reciprocity agreements with such countries, if landing rights and orbital position allow.

Assuming that Nicaragua launches a satellite and leverages the asset to the greatest possible degree, it should still take a closer look at the economics of the different access technologies and the crossing points, particularly for the middle mile. Thus, a careful analysis of various options is recommended, including the use of a mixed backhaul network to link to remote cell sites. These should include the use of the satellite planned for launch, as well as the use of point-to-point and multipoint microwave, and even fiber in specific instances.

A new governance model may be needed to link the various stakeholders effectively using the satellite platform and the hybrid backhaul/offload alternatives. For example, Nicaragua already has a functioning cable infrastructure. Consequently, it could attempt to speed up universal access through cable technology upgrades.

This combination of specific recommendations suggests that in the medium term, Nicaragua should consider developing a comprehensive technology and platform-independent state-run infrastructure enterprise with non-discriminatory open-access provisions. Such an entity could act as a catalyst for in-country development and innovation in ways



that would maximize existing resources to bridge the digital divide.

## SUMMARY AND KEY RECOMMENDATIONS FOR NICARAGUA

Nicaragua faces a number of important challenges for the expansion of broadband access, including low disposable income levels, a largely poor population, and a lagging telecom infrastructure (Box 6.2). Thus, the government's role as a leveler for business opportunities and broadband access is very important.

Although the details of Nicaragua's NicaSat satellite program have yet to be publicly disclosed, the fact that the country plans to launch and operate a domestic satellite system requires leveraging this future resource to the maximum extent and incorporating it into a comprehensive national broadband plan. Such a play would facilitate network development of all telecom sub-sectors including IP, trunking for fixed telecom and cable operators, wireless backhaul of 3G, and residential or community satellite broadband.

The Nicaraguan government should consult with international satellite market experts to develop a detailed analysis of options, both in terms of satellite

coverage tradeoffs (if there is still room for modifications) and public-private partnerships to develop an efficient and cost-effective distribution chain for the hybrid use of the satellite resources.

The ultimate goal is to develop a framework and governance model to best leverage future satellite resources as a catalyst for economic development and the expansion of broadband access. This must be done in a way that does not lead to higher costs for satellite capacity, compared to the cost of introducing capacity offered by international HTS satellite operators and sold on the open market.

## REPUBLIC OF PERU

### *Geography and Socioeconomic Data*

Peru has a total land area of 1,285,216 km<sup>2</sup> (496,225 mi<sup>2</sup>) in the western part of South America (Peruvian State Portal, 2015). With around 31 million inhabitants, it is the fifth most populous country in Latin America after Argentina, Brazil, Colombia, and Mexico (Figure 6.11).

As of 2015, 78.6 percent of the population lives in urban areas, and 21.4 percent (or 6.7 million) lives in rural areas. Major cities include the

### **Box 6.2 NICARAGUA: Low Access Level**

Nicaragua has an undeveloped telecom and broadband market, with the lowest mobile penetration in Central America. The regulatory agency is the Nicaraguan Institute for Telecommunications and Posts (TELCOR), and the main telecom operators are Empresa Nicaraguense de Telecomunicaciones S.A. (Claro), Telefonía Celular de Nicaragua S.A. (Telefónica Movistar), and Yota de Nicaragua. Nicaragua leases satellite capacity from the international market of global satellite operators. However, it plans to launch its own satellite, NicaSat-1, in late 2016 or early 2017. While it has a universal service obligation fund (FITEL), Nicaragua does not have a concrete national broadband plan. Key recommendations for Nicaragua include the following:

- Leverage its own satellite resources
- Consider the use of capacity from wide beam coverage of neighboring countries and develop reciprocity agreements with them
- Seek advice from international satellite market experts
- Develop a framework and governance model to best leverage future satellite resources as a catalyst for economic development and expansion of broadband access

Lima Metropolitan Area (home to over 9.8 million people), Arequipa, Trujillo, Chiclayo, Piura, Iquitos, Cusco, Chimbote, and Huancayo, all with more than 250,000 inhabitants, according to a 2007 census.

The World Bank classifies Peru as an upper-middle-income country, but its per capita GDP is lower than the regional average. In 2015, it had one of the fastest-growing economies in Latin America. The service sector is the most important economic driver and accounts for 60 percent of GDP, followed by manufacturing, at 16 percent. Construction and water/gas/electricity distribution makes up 10 percent of the country's wealth. The agriculture and fishing sector accounts for 9 percent of GDP, while mining accounts for the remaining 5 percent. Peru's main exports are copper, gold, zinc, textiles, and fishmeal; its major trade partners are the United States, China, Brazil, and Chile.

Macroeconomic stability, improved terms of trade, and rising investment and consumption have fueled recent economic growth. Although the abovementioned sectors have provided substantial

revenue, self-sustained growth and a more evenly distributed income have proven elusive. According to 2010 data, 31.3 percent of Peru's population is poor, including 9.8 percent that live in extreme poverty.

### *Climate Geography and the Use of Satellite Telecommunications*

Peru is an extremely bio-diverse country, with habitats ranging from the arid plains of the Pacific coastal region in the west to the tropical Amazon Basin rainforest in the east, and the Andean mountains, extending from the north to the southeast of the country.

The combination of tropical latitude, mountain ranges, topographical variation, and two ocean currents (Humboldt and El Niño) give Peru significant climatic variation. The coastal region has moderate temperatures, low precipitation, and high humidity, except for its warmer and more humid northern reaches. In the mountain region, rain is frequent during summer, and temperature and humidity fall with altitude up to the frozen peaks of the Andes. The Peruvian Amazon is characterized by heavy rainfall and high temperatures, except for its southernmost part, which has cold winters and seasonal rainfall.

Because of Peru's varied geography and climate, the Peruvian satellite environment tends to rely heavily on the use of C-band spectrum, which is less sensitive to signal-attenuation effects such as rain and humidity. While there are some Ku-band (and Ka-band) networks operating successfully in Peru (e.g., Gilat), the design of nationwide Ku-band satellite broadband networks must consider the varying signal-attenuating effects on a location-by-location basis. Not surprisingly, major telecom companies, especially telcos, make extensive use of satellite C-band, which offers high availability for services such as wireless backhaul. Intelsat, the traditional satellite capacity provider, continues to be the main source of satellite capacity for a wide range of applications, including wireless backhaul.

**FIGURE 6.11** Peru Population Density Map



Source: National Geographic, 2015.

## Telecommunications Environment and Internet Penetration

In terms of technological readiness, Peru trails behind Argentina, Brazil, Chile, and Uruguay. However, Peru's economic expansion has made it one of the most promising telecom and satellite markets in the region, with strong growth rates projected for the coming years. Growth prospects are hampered by a lagging telecom infrastructure. There is headroom for substantial improvements in key telecom metrics, ranging from fixed-line teledensity to mobile, pay TV, and Internet broadband penetration.

To a large degree, low telecom penetration levels reflect the combination of geographic challenges and the country's low-income population in many areas of the country. Therefore, Peru is very permeable to distance-indifferent satellite solutions, given the right economic conditions. The Peruvian telecom market also presents wide disparities, with fixed-line and mobile subscribers highly concentrated in urban areas, particularly Lima.

Fixed-line connectivity is a particular challenge for the widespread adoption of broadband. With 11.26 telephone lines per 100 inhabitants, Peru's fixed-line teledensity is the third lowest in South America, after Bolivia and Paraguay. Obstacles to fixed-line growth include widespread poverty, fixed-to-mobile substitution, the high cost of telephone services, and geographical inaccessibility in several regions. There is limited competition in the fixed-line environment. A great percentage of broadband is provided using the copper network (ADSL) of Telefónica del Perú, which is still a dominant platform. Thus, without competitors providing nationwide coverage, market concentration in the fixed-line business limits competition.

Low teledensity and a lagging fixed-line infrastructure have a direct effect on broadband penetration. At 40.2 percent, fixed broadband subscriber penetration is low. For a country where Internet user penetration was remarkably high in the early days of dial-up Internet, the poor development of fixed broadband may seem surprising.

There are, however, reasons for such gap. Besides poverty, literacy, low computer penetration, and rugged topography, the most prominent problem is the lack of fixed-line competition, which has made fixed broadband in Peru one of the slowest and most expensive in the region.

The mobile environment provides a different picture. Although Peru's mobile connection penetration (over 98 percent) is below that of comparable economies in the region, it is commensurate with the country's per capita GDP. Nevertheless, the mobile penetration data obscure the fact that about one quarter of the population has no mobile phones at all, while many urban Peruvians have multiple mobile connections or subscriptions.<sup>33</sup>

### Main Telecom Players

The Peruvian telecommunications market fully relies on foreign investment. Telefónica del Perú dominates the fixed-line telephone market. América Móvil's Claro occupies a distant second place, and Americatel is third, with only about 1 percent of the market.

Paradoxically, despite the low teledensity level and lack of fixed-line competition, the ITU data for 2013 reflects that 39.2 percent of Peruvians use the Internet. Two factors explain the wide gap between the low fixed broadband penetration and moderate Internet use:

- Around half of Peru's Internet users access the Internet through privately owned telecenters known as public kiosks, or *cabinas públicas*.
- The use of mobile Smartphones is pushing users to access the Internet through mobile 3G networks.

<sup>33</sup> Note that high mobile penetration can be a misleading metric due to the fact that mobile subscriptions may also count prepaid mobile "connections," which for many countries results in counterintuitive mobile penetrations of over 150 percent (such as Argentina with 162 mobile subscriptions per 100 inhabitants). An analysis conducted by GSMA Intelligence in 2014 clearly makes the distinction between mobile "connections" and "unique mobile users".

The mobile operators are Telefónica del Perú (trading as Movistar), América Móvil Perú (trading as Claro), ENTEL Peru (former Nextel del Peru), and newcomer Viettel Perú (trading as Bitel).<sup>34</sup> Viettel has pledged to invest US\$324 million in infrastructure and set-up costs to roll out mobile services.

In 2014, the mobile market in Peru grew by 6.4 percent and reached 31 million lines, as reported by the Supervisory Agency for Private Investment in Telecommunications (OSIPTEL). According to OSIPTEL, Movistar continues to lead the market with 17.3 million lines; Claro has 12.5 million lines, ENTEL Peru reached 1.7 million, and Bitel reached 323,000 lines. Prepaid cell phone lines represent 69 percent of the market for mobile telephony in the country, where Movistar and Claro have a share of 56.8 percent and 38 percent, respectively. As for postpaid or subscription-based lines, Claro leads with 69.21 percent. Movistar reduced its stake from 30.63 percent to 29.32 percent because ENTEL and Bitel gained market share in segments dominated by Movistar.

### **Telefónica del Perú S.A.A.**

Peru's largest telecommunications operator, Telefónica del Perú, provides fixed, mobile, and public telephony, domestic and international long distance, Internet, fax, and cable TV services. Spain's Telefónica Internacional acquired Telefónica del Perú after it was created in 1995, through the merger of two state-owned companies, ENTEL Perú and Compañía Peruana de Teléfonos (CPT).

### **América Móvil Perú S.A.C. (Claro Perú)**

The Peruvian América Móvil Perú (Claro), a wholly owned subsidiary of Mexico's América Móvil, was formed by the merger of TIM Peru and Sercotel, and now operates under the brand name Claro. It is a wireless telecommunications carrier and GSM operator in the country. Claro offers domestic and long-distance services, prepaid cards, and text messaging on GSM handsets. Claro is based in Lima.

### **Americatel Perú S.A.**

The Peruvian telecom services operator Americatel, a subsidiary of Chilean telco ENTEL, provides a range of products and services, including Internet and long-distance services, fixed telephony, and data transmission, mainly oriented to the small and medium-sized enterprise segment in Lima. It operates through an interconnected network using fiber optics and satellites. Founded in 2002 and based in Lima, Americatel obtained 4G spectrum in the 1,710–2,110MHz band in 2013, and a license valid for 20 years.

### **ENTEL Perú S.A. (formerly Nextel)**

In 1998, ENTEL Perú launched operations in the country under the brand name Nextel del Perú. It provides mobile communications solutions for business customers and consumers and offers fully integrated wireless communications, digital telephone interconnection, text/numeric paging, and wireless Internet access services. It started offering 4G/LTE services in 2014. The firm became a subsidiary of the Chilean telecom group ENTEL in 2013, when it was acquired from a U.S.-based company, NII Holdings, for US\$400 million. The company was rebranded ENTEL Perú in 2014.

### **Bitel (Viettel Perú)**

This new mobile network operator in Peru is a wholly owned subsidiary of Viettel Vietnam. Outside Vietnam and Peru, Viettel has operations in Laos, Cambodia, East Timor (Timor Leste), Mozambique, Cameroon, and Haiti.

### *Policy and Regulation*

Peru has a welcoming and relatively open regulatory environment, with no foreign ownership restrictions.

<sup>34</sup> See <https://www.osiptel.gob.pe/categoria/enlaces-empresas-operadoras>.



In general, to operate as a telecom player in Peru, service providers must only obtain an authorization to provide broadband or ISP services. Peru's single concession regime allows all telecom services to be provided, including fixed-line, mobile, pay TV, and Internet. The government favors foreign investment and follows pro-business and pro-growth policies. With GDP expected to continue expanding over the next several years, Peru's telecom sector is a promising arena for investors.

The regulatory authority of the Peruvian telecom services sector is OSIPTEL. It was created on July 11, 1991, by Legislative Decree No. 702. It began operations with the installation of its first Board of Directors on January 26, 1994.

OSIPTEL is a decentralized public entity responsible for regulating and supervising the market for public telecommunications services, regardless of the operating companies. It is supervised by a selected board of directors (Figure 6.12). The agency has several powers to carry out its regulatory functions, including regulation and oversight, intervention and enforcement, and dispute resolution.

OSIPTEL regulates, oversees and monitors, within its sphere of competence, market developments of public telecommunications services and the performance of the operating companies, with the goal of guaranteeing the quality and efficiency of service, regulating the market rates, and facilitating an efficient use of public telecommunications services.

While each operating company determines telecommunications tariffs according to market conditions, OSIPTEL may also set fees for some services. Through its supervisory function, OSIPTEL verifies compliance with the legal, contractual, and technical obligations of the operators. OSIPTEL may, on matters within its purview, analyze elements that are not provided for in Peru's Telecommunications Act, and may determine the appropriate corrective actions. For example, in May 2015, OSIPTEL announced that it would apply a 0.34 percent reduction to the maximum fixed telephony tariffs of main operator

Telefónica del Perú. OSIPTEL said that the reduction corresponds to the triennial review of the productivity factor pursuant to the provisions of the concession contract signed with the operator back in 2001.

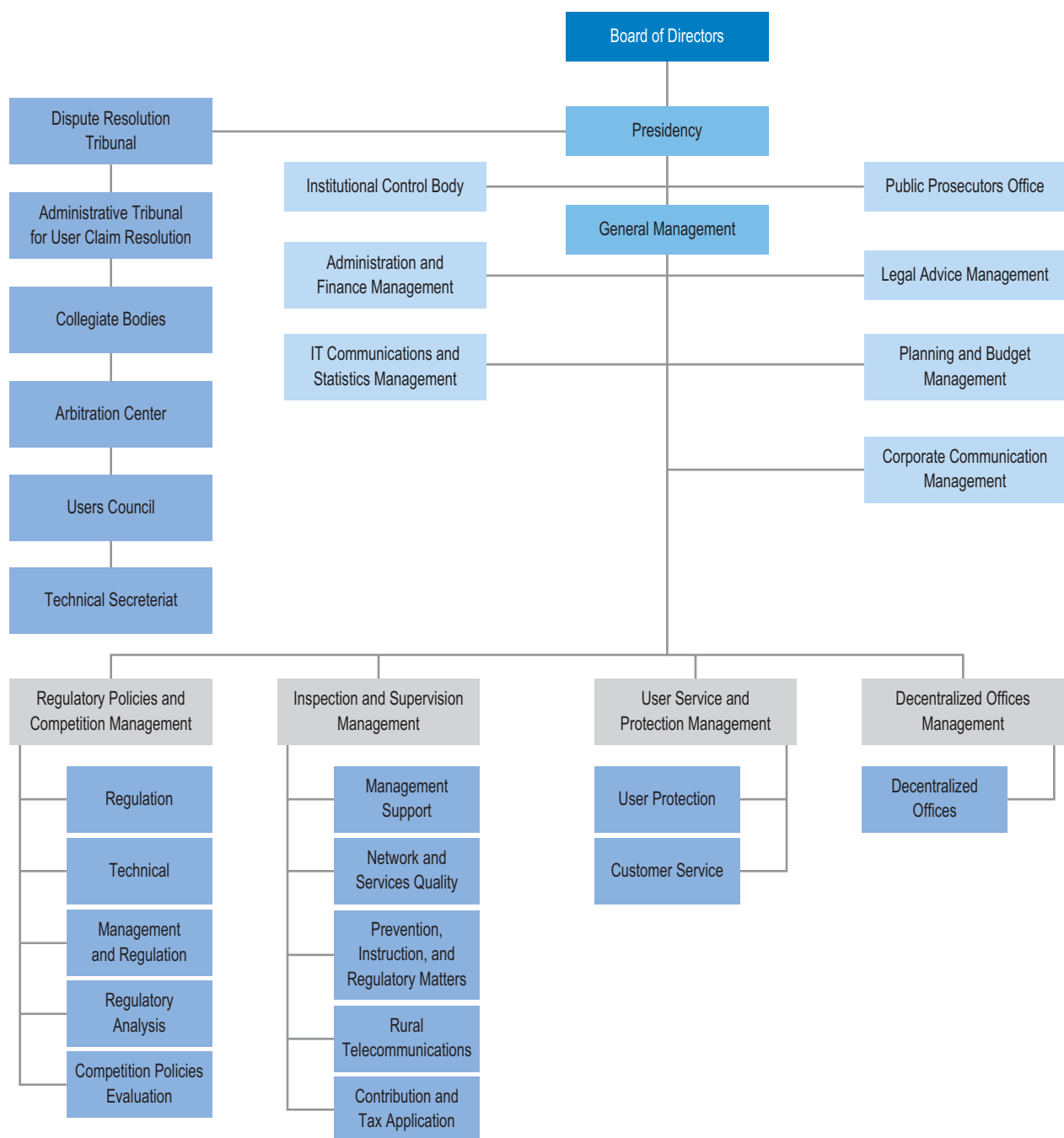
### *National Broadband Plan*

Given the abovementioned geographic and competitive and income challenges, the Peruvian terrestrial infrastructure needs substantial investment and development. Fiber optics generally serve the coastal locations well, but this is not the case in rural inland areas. Even some relatively large cities in Peru do not have fiber optic interconnection with the rest of the country. Putting the country's electric power grid map side by side with the terrestrial telecommunications network is a good way to visualize the gaps. A good example is Iquitos, the largest city in the Peruvian rainforest, and the fifth-largest city in Peru. Iquitos has a population of around 500,000 and still relies on satellites to connect it with the terrestrial fiber backbone. The government's national broadband plan, enacted in July 2012, is expected to fill the gaps and drive long-term market growth.

In 2011, the government created the Temporary Multi-sector Commission, composed of representatives of public organizations linked to the telecommunications industry. The Commission's task was to create the National Plan for Broadband Development in Peru. In this document, the Commission presented goals, objectives, and policy proposals for broadband development in the country. It established four goals to be achieved by 2016.

The first two goals were that 100 percent of municipalities, education centers, police stations, state institutions, and health establishments in urban areas, and most importantly in rural areas, must have broadband connections with a minimum speed of 2 Mbps. The third goal was to achieve 4 million broadband connections nationally, while the fourth involved achieving 500,000 broadband connections with speeds of over 4 Mbps.

**FIGURE 6.12 OSIPTEL's Organizational Chart**



Source: OSIPTEL, 2015.

To achieve these goals, three general objectives were defined. The first was linked to the supply of infrastructure and services, the second to stimulating demand and digital inclusion, and the

third to reinforcing and modernizing the institutional framework.

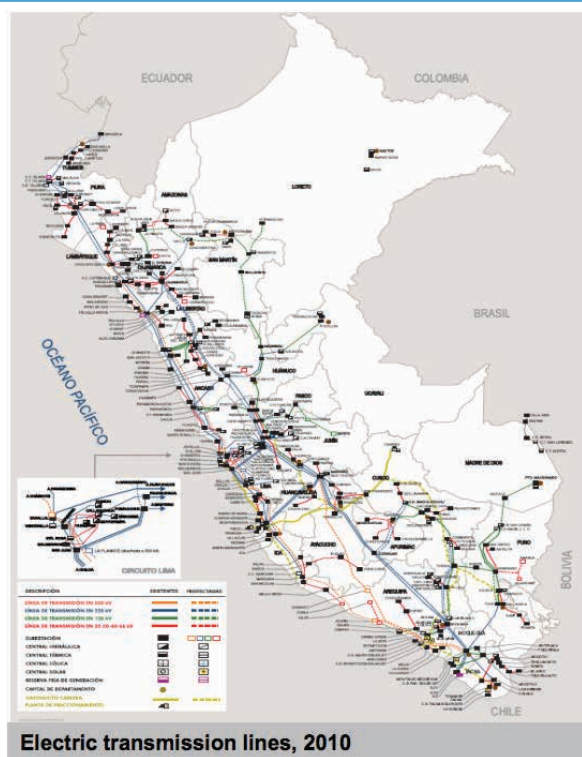
The first objective addresses the deployment of infrastructure and the promotion of competence. It



**FIGURE 6.13 Peru – Fiber versus Electric Transmission Lines**



Source: Government of Peru, 2010a.



Source: Government of Peru, 2010b.

was suggested that a fiber optic backbone should be built and regulatory measures created to encourage competition. In this regard, there are proposals to use a public-private partnership, through an agreement between the government and a private company, to deliver the infrastructure, either partially or totally. Another proposal, to prevent the backbone from being contracted out to a single operator, was to divide it between three networks. At the same time, it was hoped that the concessionaires of public telecommunications services would make the investments required for access networks, except in remote areas, for which public-private partnerships were also recommended. To promote a competitive environment that prevented monopolistic behavior, the Commission recommended adapting regulatory schemes similar to those in other countries, such as open access: a neutral wholesale market operator not participating in the retail market, with regulation of wholesale tariffs.

Concerning the second objective of stimulating demand, recommendations included the elimination of the tax on computer sales, the provision of connectivity in all public seats and organizations, the promotion of e-government, the creation of digital content, and the development of a plan to train the population in technological skills. It is unclear if the Commission's recommendations have been formally adopted and how much of the promised funds were actually committed. The document indicates Peru's intention, at least in the long term, to foster development in the sector.

### Funding

Peru has a defined universal service obligation policy. Peru's Telecommunications Investment Fund (FITEL) provides subsidies for telecom services in rural areas and other places that are marginal to commercial providers. Moreover, to increase

competition, the telecom regulator OSIPTEL has cut certain interconnection fees by up to 68 percent, with rural operators being charged lower rates.

During its 15 years of existence, the fund's development has shifted focus from financing infrastructure to a more integrated approach where projects are meant to be implemented with a sociological, as well as technical perspective, including training, raising digital awareness and development of content.

While the original Broadband Plan has experienced delays, the government has recently taken steps toward the goal of expanding broadband access in rural areas. In May 2015, the Ministry of Transport and Communications (MTC) signed agreements to authorize the development of four projects, which aim at providing remote areas with broadband access to government institutions, including education, health, and interior sectors.

Peru has recently launched the following broadband projects:

- MTC and Gilat Networks Peru (2015): three-project financing agreement on "Implementation of Broadband for Comprehensive Connectivity and Social Development" to enable connection in the Apurimac, Ayacucho, and Huancavelica regions. The Gilat Group is composed of companies "Gilat to Home Peru" and "Gilat Satellite Networks Israel." It is a well-entrenched satellite player in Peru, which has always been present in government-sponsored programs requiring satellite connectivity.
- MTC and Telefónica del Perú (2015): project-financing agreement known as "Broadband Comprehensive Connectivity for the Social Development of the Northern Zone - Lambayeque region."
- Peru's ProInversión and Mexican consortium TV Azteca-Tendai (2013): a contract to deploy a nationwide fiber optic backbone system (as reported by the state news agency Andina). The project is part of a plan to take broadband access to underserved areas and includes the deployment of 13,400 km of fiber optic cable,

linking 22 regional capitals and 180 provincial capitals. The fiber optic backbone will enable the provision of public telephony services in 782 towns and cities across Peru and will take broadband services to 758 communities, according to ProInversión. According to the MTC, the project will require a total investment of US\$400 million.

These projects aim at the implementation of an optical transport network as a backbone, and an access network for local connections. They are expected to benefit 2,380 public institutions, such as schools, health facilities, and police stations, and they will cover the demands of 1,344 towns and benefit over 747,000 Peruvians. The co-financing required by the awardees was approximately US\$350 million. FITEL will provide this amount.

### *Satellite Operation and Acquisition*

The combination of the following factors make Peru one of the most active and promising countries in Latin America for the provisioning of satellite services:

- An extensive and challenging geography that can discourage, deter, or impede the expansion of terrestrial networks
- A population density that is less concentrated in its capital city compared to other Latin America countries
- A sizable rural population of around 7 million
- An upper-middle per capita GDP, with a substantial urban-rural income gap
- An heterogeneous climate, encouraging the use of satellite as a middle-mile solution
- A relatively open, enabling regulatory environment
- Broadband policies and a universal service obligation fund (FITEL) in place; and
- Use of satellite capacity for telecommunication links, including wireless backhaul, enterprise VSAT, and rural broadband

Despite the efforts to bring fiber optics to an increasing number of cities and towns in the country, terrestrial fixed-line broadband connectivity in the last mile is not expected to expand rapidly. Thus, the efforts by the Peruvian government to expand the fiber network will bring, over time, improvements to Peru's core backbone network, but there will be many gaps to be filled by terrestrial, wireless, or satellite solutions for the middle and last miles (see Figure 6.13 above).

Because of these factors and the country's low fixed broadband penetration, 3G and 4G/LTE services are likely to boom in the coming years, beginning in urban areas but gradually expanding into remote towns, pushed by the roadmaps developed by the regulator. With the expansion of these wireless networks and the declining price of laptops and smartphones (facilitated by lower customs duties), it is natural to expect that mobile broadband and 3G/LTE phone-based Internet browsing will escalate.

Satellite communications are, and will remain, a core component for the expansion of broadband networks in Peru. While the use of last-mile satellite solutions, such as those provided by Gilat, will continue to expand, Peru is currently the second-largest user (after Brazil) of satellite capacity for wireless backhaul in the region.

Recent announcements concerning the entry and investment of new mobile players (Bitel and ENTEL), as a result of a mobile spectrum auction process, certainly seem to point in the direction of increasing demand for use of cost-effective satellite solutions as middle mile, backhaul connectivity to remote 3G and LTE wireless towers.

### Proposed Solutions

Looking forward, there are several options for Peru in terms of how to leverage satellites for expanding broadband access, both in the middle and last miles:

- **Open HTS Platforms for Wireless Backhaul:** Peru is a frequent user of satellite capacity from traditional satellite operators such as Intelsat. These pre-existing relationships, coupled with

the fact that Peru already has a user base that relies on satellite connections for wireless connectivity, means that it would be natural to expect that telcos and mobile operators, including Movistar and Claro, will leverage the advantages of platforms, such as Intelsat's Epic<sup>NG</sup>, to migrate to HTS. HTS is more economically viable than conventional GEO satellites. A lower cost per bit, enabled by these open HTS platforms, will in turn make 3G and LTE wireless backhaul over satellite more affordable. It will also allow mobile operators to achieve a positive business case on these links, which is currently difficult to achieve via traditional and expensive satellite capacity. If the business case for the rural expansion of 3G and LTE proves elusive, it is recommended that Peru explore the use of FITEL funding to stimulate and/or subsidize wireless backhaul satellite links.

- **Consumer Satellite Broadband:** Peru is already leveraging satellite broadband systems, such as Gilat, for rural broadband connectivity. However, it should conduct a forward-looking analysis of the economics and architecture of HTS broadband systems and the demand for residential broadband. Open HTS platforms, such as Intelsat's Epic<sup>NG</sup>, can be used for consumer broadband access. It is recommended that Peru consider the use of Ka-band networks where climatic conditions do not negatively affect the use of this frequency band. Telefónica's Media Networks already provide such a platform but have limited coverage. However, it is possible that satellite operators, such as Hispasat, for example, in cooperation with the Telefónica group, would deploy substantially more Ka-band capacity in Peru and other countries. This could be used as both a last- and middle-mile solution.
- **National Satellite:** Peru does not have a national satellite program in place, but its sheer satellite market size could serve as a baseline for the government to explore such an initiative. However, domestic satellite systems do not necessarily make sense financially

when compared to large commercial systems. Possibly in cooperation with neighboring Colombia and Chile, a government-sponsored system provided by one of the existing commercial operators could be considered, with a model similar to the one used by NBN Co. in Australia. This would consist of a combination of wide and spot beams, using both Ka and Ku bands. Peru signed a contract with Airbus Defense and Space in 2014 for the delivery of an earth observation satellite for defense purposes. Following this entry into space technology, Peru could consider an expansion into broadband telecommunications by satellite.

## SUMMARY AND KEY RECOMMENDATIONS FOR PERU

Peru has many characteristics that would enable it to leverage satellite communications as a means to increase its broadband penetration and bridge the digital divide. It has a vast geography with sizable rural population of over 6.5 million, a lagging telecommunications infrastructure (largely driven by its geographic challenges and a dispersed population), a growing economy, and a high degree of openness to foreign investment.

Peru also has a national broadband plan with a defined universal service obligation policy (FITEL). While Peru's broadband plan does not place particular emphasis on satellite solutions, satellites are currently playing a major role in broadband access, particularly to reach remote areas via satellite backhaul solutions to wireless and fixed telecom players.

Following are the key final recommendations for Peru as they relate to this study:

- Mobile broadband access must be acknowledged as a main technology to bridge the digital divide, and as such should be addressed in the country's national broadband plan.
- The use of satellite technology for cellular backhaul, as well as last mile/consumer broadband should be included in the national broadband plan.
- Mobile Network Operators (MNO) must continue to leverage satellites for wireless backhaul, but must also plan for a transition to HTS that will enable 3G and 4G/LTE backhaul. Satellite open platforms are ideally suited for HTS backhaul.
- OSIPTEL needs to assess the economics of 3G/LTE wireless backhaul via HTS platforms. An assessment would enable the regulator to develop and implement economically viable wireless broadband deployment plans for 3G and LTE.
- Key information and analysis of the wireless-backhaul business cases will provide the tools for the regulator to improve enforcement of the expansion of mobile broadband in remote or rural locations. MNOs will then need to comply with the strict deployment plans developed by the regulator. Such plans should consider socioeconomic and population density metrics, with the goal of gradually expanding mobile broadband toward municipalities that struggle with attracting businesses.
- Whenever an analysis of the wireless-backhaul economics leads to cases with marginal business case results for the MNO (even with the use of HTS and cellular backhaul optimization technology), then the regulator will need to consider use of subsidies via the FITEL fund.
- While it is expected that wireless satellite backhaul will remain the main cost-effective approach in terms of bridging the digital divide, consumer broadband satellite solutions should be considered, particularly if Peru can use Ka-band spot beam technologies to bring down the cost of satellite capacity substantially.
- The government and the regulator should analyze the case of a national satellite program, given its potential advantages as an infrastructure leveler. While the results of this study cannot be conclusive as to the effectiveness of such a program, Peru can make a better case for it than some other countries in the region that are pursuing similar programs.

### Box 6.3 PERU: Medium Access Level

Telecommunications penetration in Peru is low due to a combination of geographic challenges, lagging telecom infrastructure, and low income levels in many regions. The Peruvian satellite environment tends to rely on the use of C-band spectrum, with few Ku and Ka-band networks operating. The regulatory agency is OSIPTEL, and the main telecom operators are Telefónica del Perú, América Móvil Perú, ENTEL Perú, and Viettel Perú. Through its national broadband plan, Peru aims to have broadband connection in 100 percent of municipalities, education centers, police stations, state institutions, and health establishments in urban and rural zones; achieve 4 million broadband connections nationwide, minimum broadband speed connection of 2 Mbps, and 500,000 broadband connections with speeds over 4 Mbps. Key recommendations for Peru include, among others:

- Use satellite technology for cellular backhaul
- Plan a transition to HTS to enable 3G and 4G/LTE backhaul
- Assess the economics of 3G/LTE wireless backhaul via HTS platforms
- Establish a national satellite program

## REPUBLIC OF TRINIDAD AND TOBAGO

### *Geography and Socioeconomic Data*

Located in the Caribbean region, Trinidad and Tobago shares maritime boundaries with other nations including Barbados to the northeast, Grenada to the northwest, Guyana to the southeast, and Venezuela to the south and west.

The twin-island nation consists of the two main islands, Trinidad and Tobago, and numerous smaller islands: Chacachacare, Monos, Huevos, Gaspar Grande (or Gasperee), Little Tobago, and St. Giles Island. Trinidad is 4,768 km<sup>2</sup> (1,841 mi<sup>2</sup>) in area (comprising 93 percent of the country's total area), while Tobago has an area of about 300 km<sup>2</sup> (120 mi<sup>2</sup>), or 5.8 percent of the country's area. The official language is English.

About 96 percent of the country's 1.3 million inhabitants reside on the island of Trinidad, with the remainder living on Tobago and the other islands. Only 8.4 percent of the population is considered urban, based on a 2014 report by the United Nations' Department of Economic and Social Affairs and Population Division (UNDESA, 2014). As of 2015, Trinidad and Tobago has a rural population of about 1.2 million.

A good infrastructure by regional standards, including an extensive network of paved roads and highways, supports rural life. Utilities are reliable in the cities. Some areas, however, especially rural districts, still suffer from water shortages.

Most towns and cities are located on the island of Trinidad. The three major municipalities are Port of Spain (the capital), San Fernando, and Chaguanas. The main municipality on Tobago is Scarborough.

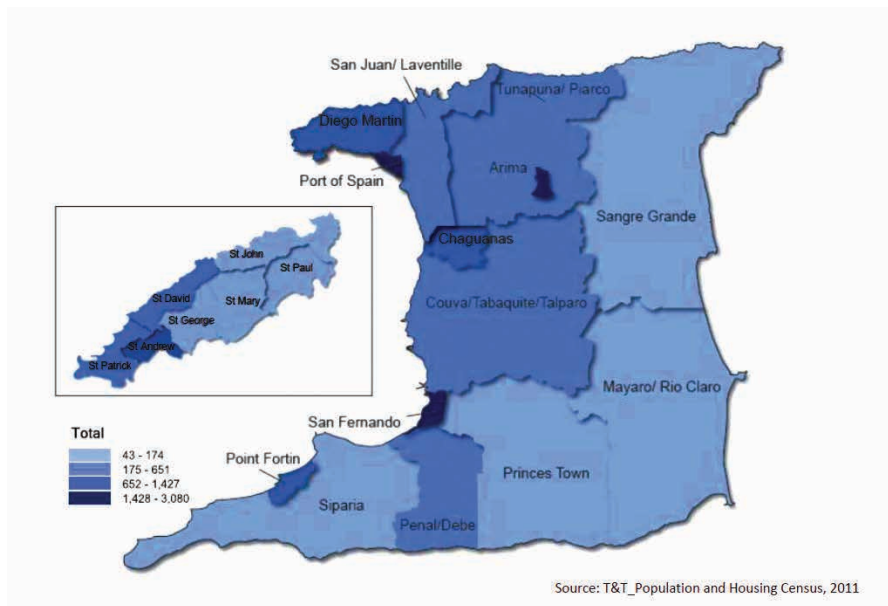
Trinidad and Tobago is one of the wealthiest and most developed nations in the Caribbean. Its per capita GDP is US\$18,219. The World Bank recognizes Trinidad and Tobago as a high-income economy. Unlike most English-speaking Caribbean countries, Trinidad and Tobago's economy is primarily industrial, with an emphasis on petroleum and petrochemicals. The country's wealth is mainly attributable to its large oil reserves and exploitation of oil and natural gas, which account for about 40 percent of GDP and 80 percent of exports, but only 5 percent of employment.

### *Climate Geography and the Use of Satellite Telecommunications*

Trinidad has an average length of 80 km (50 mi), and an average width of 59 km (37 mi). Tobago is



**FIGURE 6.14** Trinidad and Tobago: Population Density Map



Source: Government of Trinidad and Tobago, 2011.

41 km (25 mi) long, and 12 km (7.5 mi) at its greatest width. With respect to satellites, a single high-speed satellite spot beam using either C-band, Ku-band, or Ka-band could cover the entire country. O3b beams, for example, are typically around 700 km in diameter.

The islands' terrain is a mixture of mountains and plains. The highest point in the country is the Northern Range at El Cerro del Aripo, which is 940m (3,080 ft.) above sea level.

The climate is tropical, thus, not ideal for rain-sensitive Ka-band satellite solutions. There are two annual seasons: the dry season for the first six months of the year, and the rainy season in the second half of the year.

Unlike most of the other Caribbean islands, Trinidad and Tobago has frequently escaped the wrath of major devastating hurricanes, including Hurricane Ivan, the most powerful storm to have passed close to the islands, in September 2004. In the Northern Range, the climate is often different from the sweltering heat of the plains below. With constant cloud and mist cover and heavy rains in the mountains, the temperature is much cooler.

### **Telecommunications Environment and Internet Penetration**

Telecommunications services are relatively modern and reliable. Cellular network availability is widespread and has been the major area of telecom growth for several years. Growth and competition drive the country to high penetration levels. For the third consecutive year, the World Economic Forum (WEF) ranked the country number one in global information technology for mobile coverage out of 143 countries.

According to a 2014 report issued by the Telecommunications Authority of Trinidad and Tobago (TATT), the country has a high mobile phone penetration of 149.1 percent (TATT, 2014). As for Internet penetration, the country has a rate of 65.1 percent.

### **Main Telecom Players**

Telecommunications Services of Trinidad and Tobago Limited (TSTT) is the largest telephone and Internet service provider in Trinidad and Tobago.



The company, jointly owned by the Government of Trinidad and Tobago (51 percent) and Cable & Wireless (49 percent), branded as CWC or Lime, was the result of the merger of Telco (Trinidad and Tobago Telephone Company Limited) and Textel (Trinidad and Tobago External Telecommunications Company Limited).<sup>35</sup>

While still dominant, TSTT no longer holds a monopoly on fixed-line telephone services. Columbus Communications (under the Flow brand) introduced fixed-line services, including cable TV, broadband, and telephony. TSTT's cellular monopoly was also broken in 2005 when licenses were granted to Digicel and Laqtel. Laqtel, however, never started the business. TSTT then added B-mobile to the market in 2005 as a subsidiary of TSTT, catering to the mobile telephone market.

Therefore, the current fixed line operators are TSTT and Flow, while the mobile network operators in the country are B-mobile (TSTT) and Digicel. In April 2015, Trinidad and Tobago News reported that TATT recommended the introduction of a third mobile operator to obtain a license from the Cabinet. As of July 2015, the TATT has not revealed the identity of the company. This recommendation seems to validate the fact that, despite the government's strong intervention and direct retail play (it is the majority shareholder in TSTT), the country is taking steps toward greater openness and liberalization for telecom services.

The operators that applied for a mobile license are Cable & Wireless Communications (Lime), Columbus Communications (Flow), Suriname state-owned telco Telesur, and Star Mobile Caribbean. The third mobile service provider is expected to boost competition and greater affordability, wider choice, and faster speeds.

Cable & Wireless (Lime) attempted to purchase Columbus International Inc. (Flow) for US\$3.025 billion in November 2014, because of Columbus' attractive and sophisticated network, backed by state-of-the-art terrestrial and submarine fiber assets. However, to prevent Cable & Wireless from dominating the fixed-line business, TATT denied the proposed Lime/Flow merger. As a condition of the

regulatory approval for the Columbus acquisition, Cable & Wireless is required to divest its 49 percent stake in TSTT and no longer retain significant influence over its management. Mobile operator Digicel also complained about the potential distortion to the fixed-mobile landscape that such merger could cause. Cable & Wireless and Digicel are common players in the Caribbean and Central America. Thus, neither of them is limited to conducting business only in Trinidad and Tobago. Nevertheless, on March 2015, Cable & Wireless announced that it has completed its acquisition of 100 percent of the equity of Columbus International Inc. (*Cable & Wireless*, 2015).

## TSTT

Telecommunications Services of Trinidad and Tobago Limited is jointly owned by National Enterprises Limited (NEL), whose majority shareholder is the Government of Trinidad and Tobago, and Cable & Wireless (West Indies) Limited, (C&W). NEL owns 51 percent of TSTT's issued share capital, while C&W holds 49 percent. TSTT is the country's largest provider of communications solutions to the residential and commercial markets. Some of its products and services are marketed under its BLINK and B-mobile brands.

## Columbus Communications (Flow)

Columbus Communications is a cable television and broadband high-speed Internet service provider. Columbus operates as a regional media company. Currently based in Barbados, it provides services in the Bahamas, Grenada, Jamaica, and Trinidad and Tobago. The company's operations in the Bahamas are branded as Cable Bahamas, while its operations in other countries are branded as Flow. As of March 2015, the company was acquired by Cable & Wireless Communications, the parent company of

<sup>35</sup> See <http://tatt.org.tt/Telecommunications/ServiceProviders.aspx>.

another fellow telecommunications company in the Caribbean, named Lime. The cost of the acquisition was US\$1.85 billion (*Cable & Wireless, 2015*).

## Digicel

Digicel Group Ltd. is a global communications provider with operations in 33 markets in the Caribbean, Central America, and Asia Pacific. The company is located in Kingston, Jamaica. After 13 years of operation, total company investment stands at over US\$5 billion worldwide.

### Policy and Regulation

The Telecommunications Authority of Trinidad and Tobago (TATT) is the telecom regulator of Trinidad and Tobago (Figure 6.15). TATT was established in 2001 by the Telecommunications Act as the independent regulatory body responsible for the transformation of the telecommunications sector from a virtual state-owned monopoly to a hybrid competitive environment.<sup>36</sup>

The Authority is responsible for the gradual liberalization of the telecommunications sector and for regulation of the telecommunications and broadcasting sectors. It manages spectrum and phone number resources, establishing equipment

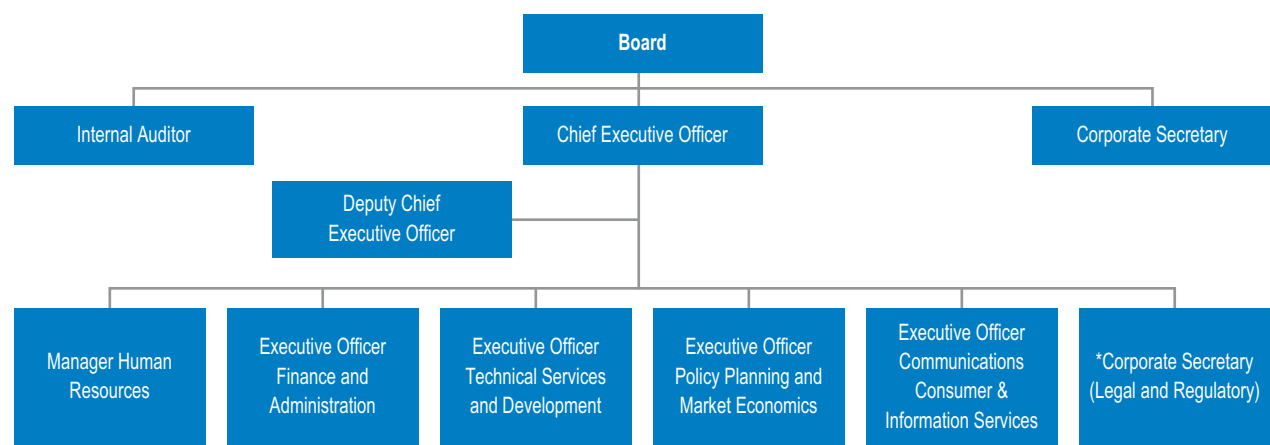
and service quality standards, setting guidelines to prevent anti-competitive practices, and encouraging investment in order to facilitate the availability of affordable telecommunications and broadcasting services. It is administered by a board of directors consisting of a chairperson, a deputy chairperson, and nine other members appointed by the president. The board oversees the activities of the authority and appoints a chief executive officer who manages the affairs of the Authority subject to the directions of the board.

The TATT is responsible for facilitating the orderly development of the telecommunications and the broadcasting sectors. While the regulator has linkages with the Ministry of Science and Technology, it enjoys a high degree of freedom and independence. Its functions include:

- Granting licenses and making recommendations to the Ministry of Science and Technology on the granting of concessions
- Classifying telecommunications networks and services

<sup>36</sup> See Telecommunications Act, 2001, Part II (4). Available at [http://tatt.org.tt/Portals/0/Documents/Tele-communications percent20Act percent202001.pdf](http://tatt.org.tt/Portals/0/Documents/Tele-communications%20Act%202001.pdf).

**FIGURE 6.15** TATT's Organizational Chart



Source: Government of Trinidad and Tobago, 2010.

- Determining universal service obligations throughout Trinidad and Tobago to ensure that all citizens have access to telecommunications services
- Establishing national telecommunications and broadcasting industry standards
- Advising the minister on technical standards and policies governing the telecommunications and broadcasting industries and issues arising at international, regional and national levels
- Ensuring compliance with ITU conventions
- Planning, supervising, regulating, and managing the use of the radio frequency spectrum, including:
  - The license and registration of radio frequencies and call signs to be used by all stations operating in Trinidad and Tobago, or on any ship, aircraft, or other vessel, or satellite registered in Trinidad and Tobago
  - The allocation, assignment, and reallocation or reassignment of frequency bands where necessary
  - Managing and administering telephone numbers
  - Testing and certifying telecommunications and broadcasting equipment to ensure compliance with international standards, environmental health and safety standards, including electromagnetic radiation and emissions

The TATT fosters the development of competitive telecommunications and broadcasting environments to facilitate the use of ICTs for social and economic well-being. By regional standards, Trinidad and Tobago enjoys a healthy, semi-open competitive telecom marketplace, as evidenced by a high ITU competitive access index (CAI) and a growing mobile sector. However, unlike most Latin American countries, Trinidad and Tobago has not fully transitioned to a private-only telecom environment. TSTT, partially owned by the government, remains the largest fixed-line operator. It also operates a mobile company.

The Government of Trinidad and Tobago participates in telecom and other sectors through an investment holding company called National Enterprises Limited (NEL), incorporated in 1999. NEL was formed to consolidate the government's shareholding in select state enterprises, and facilitate a public offering on the Trinidad and Tobago Stock Exchange.

### *National Broadband Plan*

Trinidad and Tobago has a national broadband plan called smarTT. The smarTT National ICT Plan 2014-18 was designed with inputs from a variety of stakeholders and a diverse group of individuals representing their communities, organizations, industries, and government.

The ultimate goal of the ICT sector is to become a major contributor to GDP growth; therefore, smarTT is considered the first installment of a larger ICT roadmap. The roadmap consists of two additional five-year periods (2018-22 and 2022-26), still being defined. The Plan features the following five thematic target areas:

- Innovation and Human Capital Development
- Access and Digital Inclusion
- e-Business and ICT Sector Development
- Infrastructure Development
- E-Government

In acknowledgement that the island of Tobago, compared with Trinidad, is at a different stage of ICT readiness in terms of infrastructure, training, and access, smarTT's focus for Tobago will be placed on people-centered development, connectivity, and the extension of government services, each driven by innovation and use of relevant ICTs.

### *Funding*

There are two types of funding arrangements currently used to support the deployment of smarTT. Firstly, a central fund will be developed and implemented for cross-agency ICT shared systems, and

will subsidize the use of these systems to encourage government agencies' participation. Secondly, a fund will be set up to encourage public-private partnerships. The use of both types of funding arrangements must be reported to the National ICT Steering Committee through the smarTT Secretariat.

The National ICT Company Limited (iGovTT) will determine indicative budget estimates for each program and project in collaboration with the Ministry of Planning and Sustainable Development. The figures will be used for budgeting purposes. Thereafter, actual cost approval for program/project delivery is subject to:

- The priorities of the government at the proposed time of program/project initialization and
- The outcome of a tender for procurement of ICT goods and services for a given program or project.

### **Satellite Operation and Acquisition**

As stated in the smarTT plan, closing the broadband gap in Trinidad and Tobago will entail heavy investments in access networks as well as in the backbone infrastructure. These include the use of fiber links, possibly complemented by microwave and satellite links. As broadband wireless technologies continue to evolve, the hardest to reach areas, particularly in Tobago, must have an alternate option in wireless broadband technology.

A combination of factors indicates that Trinidad and Tobago is in a strong position to improve access metrics even further and positively change the technology landscape. They include the following:

- A high per capita GDP by regional standards
- A mobile phone penetration of 140 percent, which could be significantly leveraged to offer additional services and increase efficiencies, production, and utilization in the market
- An integrated and sustainable broadband plan

As it relates to the use of satellites to support the closing of the digital divide, the high percentage

of the rural population is typically a key driver for satellite broadband in either the last or the middle mile. Trinidad and Tobago does not intend to procure its own national communications satellite. The small geographic footprint and small satellite-addressable market compared to other countries and satellite-dependent markets in the Caribbean will likely make any national satellite program economically inviable.

Like most countries in Latin America and Caribbean, Trinidad and Tobago leases satellite capacity from global or regional satellite operators operating in the region, such as Intelsat, SES, and Eutelsat/Satmex. The region currently relies on traditional, wide-beam satellite capacity, meaning that satellite bandwidth is shared across large, multi-national territories.

### **Proposed Solutions**

Given the high mobile phone penetration, Trinidad and Tobago is positioned to improve Internet access by utilizing the already developed and competitive wireless mobile ecosystem, which is also being pushed toward more openness through the introduction of a third mobile player. Consequently, it is recommended that Trinidad and Tobago do the following:

- Satellite technology should be used as a middle-mile transmission medium, namely as a wireless backhaul solution to reach locations without any viable terrestrial backhaul alternatives, or for those that present bottlenecks, traffic saturation, and congestion. There are currently simultaneous developments in the satellite communication landscape that are pushing satellite broadband toward a synergistic play with wireless.
- Small-cell technologies should be considered because they allow mobile operators to deploy cellular access equipment cost effectively in rural areas with low population densities that do not justify the use of expensive macrocells.
- Developments in cellular backhaul optimization technology can provide substantial savings in the procurement of satellite bandwidth.

- HTS platforms will become key battleground satellite operators, with an increasing number of players committing to deploy substantial capacity in the LAC region over the 2016–18 period.

Therefore, a key recommendation is to leverage the opportunity of multiple players entering the HTS marketplace in the region and competing with each other. It is highly expected that within two or three years, frequency reutilization via spot beam technology deployed by an increasing number of players in the Caribbean, all targeting to capture a share of growing satellite mobility markets (such as aero and maritime), could lead to an oversupply scenario in specific spots and further lower the cost of satellite spectrum.

While satellite broadband links are being provisioned over traditional satellite systems, the country should work on a transition plan to HTS by closely monitoring operator’s announcements and satellite launch schedules.

One key aspect to consider for Trinidad and Tobago from both a technical and regulatory perspective is the location for the satellite gateways or teleport facilities. However, the small addressable market for satellite services implies that the country could contract HTS-managed service solutions being developed by major satellite operators (e.g., Intelsat, Hughes, ViaSat). Wireless traffic could thus leave the country to land in satellite ground systems (HTS gateways) located in countries such as the United States, which have direct access to a wide range of submarine fiber networks and neuralgic Internet peering POPs (e.g., points of presence with vast fiber interconnection such as NAP of the Americas in Miami, Florida).

In the long term, the country should consider shifting to the use of MEO constellations, which will ultimately provide higher data rates with low delay. However, user equipment cost, driven by developments in flat-panel satellite antenna technology (electronically steered antenna), will need to fall sharply before MEO satellite systems can become a viable alternative in Trinidad and Tobago.

One last point regarding national satellite programs is that it is probably not cost-effective for Trinidad and Tobago to consider a national satellite. However, the government should monitor developments in neighboring Venezuela. If Venezuela launches new generations of Venesat satellites, Trinidad and Tobago could leverage its geographic proximity to participate in that satellite capacity. However, considering the current economic situation of Venezuela and short-term prospects, this is another option should Venezuela’s economy improve in the future.

## SUMMARY AND KEY RECOMMENDATIONS FOR TRINIDAD AND TOBAGO

Thanks to its high disposable income levels, largely rural population, and strong and competitive wireless broadband play, it is recommended that Trinidad and Tobago take full advantage of satellites as middle mile, that is, as a wireless backhaul solution to reach rural locations with 3G and 4G/LTE broadband.

The Caribbean is becoming a key global battleground for HTS capacity, with an increasing number of players committed to deploy substantial transmission capacity between 2016 and 2018. This will present excellent opportunities to obtain satellite bandwidth in the open market at decreasing costs.

The following are some key recommendations for Trinidad and Tobago related to this study (summarized in Box 6.4):

- Mobile broadband access should remain the main technology to bridge the digital divide. High income relative to most countries in the region is expected to accelerate the transition toward 3G and LTE wireless broadband.
- Mobile network operators must leverage satellite solutions for wireless backhaul and should plan for a quick transition to HTS, taking advantage of the increasing number of international satellite operators that are expected to be entering the Caribbean HTS market.

#### Box 6.4 TRINIDAD AND TOBAGO: Upper Access Level

Telecommunications services are relatively modern, reliable, with widespread cellular network availability, and high penetration levels. The regulatory agency is the Telecommunications Authority of Trinidad and Tobago (TATT), and the main telecom operators are Telecommunications Services of Trinidad and Tobago Limited (TSTT), Columbus Communications (Flow), and Digicel. Trinidad and Tobago leases satellite capacity from global and regional satellite operators such as Intelsat, SES, and Eutelsat/Satmex, and there is no intention to acquire its own national communications satellite. The national broadband plan, called smarTT, features five thematic target areas: (i) Innovation and Human Capital Development; (ii) Access and Digital Inclusion; (iii) e-Business and ICT Sector Development; (iv) Infrastructure Development; and (v) e-Government. To fund smarTT, two types of funds were created: a central fund to subsidize ICT systems and a fund to encourage public-private partnerships. Key recommendations for Trinidad and Tobago include, among others:

- Maintain mobile broadband as the main technology to bridge the digital divide
  - Leverage solutions for wireless backhaul
  - Plan for a quick transition to HTS
  - Develop strategies for bulk capacity acquisition and transparent, non-discriminatory redistribution to operators
- 
- Leverage the large amount of HTS capacity entering the market, but also develop strategies to best utilize a wide range of business models:
    - Consider use of a combination of open B2B platforms (such as Intelsat Epic) and closed, vertically integrated models (Hughes and/or ViaSat).
    - Develop regulations that can enable the use of foreign satellite gateways to interconnect with terrestrial networks.
  - Given its small size relative to the larger countries in the region, it is advisable that requirements for satellite bandwidth be aggregated by a central entity in order to improve bargaining power when negotiating capacity leases with satellite operators:
    - Develop strategies for bulk capacity acquisition and a transparent, non-discriminatory redistribution to operators.
  - Seek professional assistance with regard to the use of HTS satellite resources in a way that can best be leveraged for the expansion of wireless broadband:
    - Conduct an analysis of the wireless backhaul business case and produce comparison tools for the regulator to better support the expansion of mobile broadband in remote or rural locations through a combination of terrestrial links and satellites.
    - MNOs will then need to comply with deployment plans developed by the regulator.
    - Consider the use of subsidies via a universal service fund (USF) for locations where none of the backhaul alternatives provides a positive business case for the operator.



# Satellite Solutions for the LAC Region: Final Thoughts and Proposed Steps for Implementation

---

In the previous chapter, specific recommendations for a set of focus countries were developed and presented. However, considering the overall study work performed, a large number of conclusions have been drawn, which are broadly applicable throughout the Latin American and Caribbean (LAC) region.

In general, the importance of broadband for future human development has been widely acknowledged by all stakeholders. National governments, international institutions, and the private and public sector have all acknowledged the importance of bridging the digital divide to foster economic growth, social inclusion and practically all areas of individual concern. For example, there is a clear link between broadband access and the provision of services in the areas of health care, education, government and commerce, among other applications. Of particular concern are rural communities, whose inhabitants account for more than 40 percent of the LAC region total population. However, the provision of broadband services to remote areas through terrestrial systems is costly and time consuming.

Therefore, it is essential to find the right combination of complementary technologies to bridge

the digital divide. Satellite technology, fiber optic cables, and terrestrial microwave systems are not mutually exclusive, competing technologies, but together form the inventory to be used for the design, implementation and operation of broadband systems optimized on a case-by-case basis.

Satellite broadband technology is provided to end-users directly or in combination with other technologies, when specific circumstances warrant such a combination. Satellite telecommunication represents a point-to-multipoint technology that can reach all geographic targets within a given footprint. Therefore, it instantly establishes service coverage over a region and the possibility to link many costumers to the broadband and Internet backbone network simultaneously.

The commercial telecommunications satellite industry has matured into a global and mostly private enterprise sector, independent from governments and the specific space technology requirements in the defense/military arena. Conventional geostationary satellites provide most of the satellite transmission capacity. However, new technologies are expected to improve considerably the usefulness of telecommunications satellites for

broadband services. They have recently become available for the future broadband markets, such as the high throughput satellites (HTS), and medium earth orbit (MEO) systems, like O3b.

In conclusion, satellite broadband is a proven technology provided by a mature industry. It is particularly useful for the provision of broadband services in rural and remote areas. It is therefore an essential element in bridging the digital divide in the LAC region. For this to become a reality, policymakers and regulators need to create the conditions necessary for its implementation.

The checklist below is a starting point for countries willing to utilize satellite broadband to bridge the digital divide. The following are the ten top policy elements:

- Acknowledge the urgent need to serve rural populations and ensure that it is reflected in government policies and regulations.
- Identify rural, remote, and low-population-density communities that need broadband coverage and that cannot be served by terrestrial media.
- Include satellite broadband as an available alternative and make it an integral part of any national broadband plan.
- Identify region-wide needs and develop projects that cover countries on the same satellite coverage footprint and are therefore able to share capacity.
- Acquire unbiased, professional, technical, financial, and management expertise to develop and implement a holistic, optimized network design to be applied on a case-by-case basis, and inclusive of the specific rural customer requirements.
- Consider new technologies that have become available for the future broadband markets, such as high throughput satellites (HTS), and medium earth orbit (MEO) systems like O3b.
- Consider, define, and implement financing policies, such as universal service funds, for broadband services in rural and remote areas, including broadband, tax incentives, direct

government funding for pilot projects, and CAPEX subsidies for equipment procurement.

- Identify and enter into potential partnerships with international organizations, multilateral development banks, and satellite operators for specific projects.
- Create demand for broadband services by making services affordable, increasing digital literacy, and ensuring that there is relevant local content available.
- Conduct capacity-building workshops in partnership with international organizations, on the technical and policy issues.

While all stakeholders should consider these ten general recommendations and the findings throughout this study, some of them are relevant only for certain stakeholders.

Policymakers play a decisive role in setting the stage and defining the legal, institutional, and regulatory framework for a successful and universal provision of broadband services, including a holistic vision to implement it. A solid framework will achieve lower prices, better quality of service, increased investment, public and private funding, and faster technological innovation. One effective way of defining the institutional framework for the implementation of broadband services is by elaborating national broadband plans, which can be a catalyst for the cross-ministry and cross-sectoral collaboration that is crucial for the development of broadband. National broadband plans should include generally acknowledged principles, such as net neutrality. They should be periodically updated as technology evolves and demand changes.

Regulators execute and supervise policy implementation. For satellite broadband, the main role of the regulator is to ensure that the market environment promotes competition and does not create artificial barriers to the provision of satellite broadband services. In addition, regulators should make telecommunications regulation as transparent as possible.

Regulators should also pay attention to the specific requirements and challenges of the

end-user. They should attempt to provide the five basic elements of broadband service: (i) add value to life and business; (ii) be affordable; (iii) be available when needed; (iv) have technical support available to restore service; and (v) have predictable behavior under conditions that could affect service delivery. Regulators also have to adopt a strong consumer advocacy role to protect and empower rural customers as well as those with limited knowledge of digital technologies.

This report has identified a wide range of critical topics for policymakers and regulators to consider. These include the need for public and private funding, the concept of a broadband ombudsman for rural broadband projects, principles governing the role of the internet service providers (ISPs), and the development and implementation of service-level agreements (SLAs) for all customer communities.

Considering the technical implementation and operation of broadband systems, local ISPs and network and satellite operators should be encouraged

to use satellite technology, either as stand-alone solutions or in hybrid networks in combination with other technologies, to develop optimum network architectures. This will include monitoring and possible use of the newly developed HTS technology (HTS) and MEO systems.

The intent of this study is to serve as a set of best practices to inform policymakers in the region and around the world about how to recognize their respective set of challenges and provide alternatives in advancing broadband access to constituents. However, it is important to note that national policymakers are not alone in this endeavor. Many international and multilateral organizations, such as the IDB and the ITSO who have sponsored and coordinated this study and this report, are prepared to assist any LAC country and broadband project with their expertise. These organizations can assist with project funding, capacity building for policy and regulatory aspects, gap analysis research, and brokering with satellite operators and ISPs.



# References

---

- AFTIC (Autoridad Federal de Tecnologías de la Información). 2015. "AFTIC Organizational Chart." Buenos Aires, Argentina: AFTIC.
- Airbus Defense & Space. 2016. "Airbus Defense and Space Readies EUTELSAT 9B Satellite for Launch." Plano, Texas: Airbus Defense & Space.
- AnalysysMason&Intelsat. 2010. "Taking Mobile to Rural Africa: The Vital Role of Hybrid Satellite-Microwave Backhaul." *Microwave Journal*. September 2010. Washington, DC: Intelsat. Available at <http://www.microwavejournal.com/ext/resources/BGDownload/f/4/6069-Hybrid-Backhaul.pdf?1326826607>.
- Barnes, D. and J. Halpern. 2001. "Reaching the Poor: Designing Energy Subsidies to Benefit Those that Need It." *Refocus 2.6* (2001): 32-7.
- Bauer, S., D. D. Clark, and W. Lehr. "Understanding Broadband Speed Measurements." August 2010. Telecommunications Policy and Research Conference (TPRC). Washington, DC: TPRC.
- BCDD (Broadband Commission for Digital Development). 2013. "The State of Broadband 2013: Universalizing Broadband." Geneva: BCDD. Available at <http://www.broadbandcommission.org/documents/bb-annualreport2013.pdf>.
- . 2014. "The State of Broadband 2014." Geneva, Switzerland: BCDD.
- . 2015. "The State of Broadband 2015: Broadband as a Foundation for Sustainable Development." Geneva, Switzerland: BCDD.
- BNamericas*. 2016. "Business Insight in Latin America: Argentina's Telecom Companies." Santiago, Chile: Business News Americas. Accessed 2016.
- . 2015. "Empresa Argentina de Soluciones Satelitales, S.A." Santiago, Chile: Business News Americas.
- Cable & Wireless*. 2015. "CWC/Columbus Merger Finalized." News Release. March 31, 2015.
- "China launch VENESAT-1-debut bird for Venezuela (n.d.)." Nasa Space Flight. Available at <http://www.nasaspaceflight.com/2008/10/china-launch-venesat/>.
- Chomitz, M., P. Buys, and T. Thomas. 2005. "Quantifying the Rural Gradient in Latin America and the Caribbean." World Bank Policy Research Working Paper 3634. Washington, DC: World Bank.
- CIA (Central Intelligence Agency). 2015. *CIA World Factbook*. Washington, DC: CIA.
- Clarke, A. C. 1945. "Extra-Terrestrial Relays: Can Rocket Stations Give Worldwide Radio Coverage?" *Wireless World*. October: 305-308.
- Corporacion Colombia Digital. 2013 "El Programa Vive Digital Fase II entregará 5.524 kioscos digitales." December. Bogota, Colombia: Colombia Digital. Available at <http://colombia digital.net/actualidad/noticias/item/6208-ek-origrana0vive-digital-fase-ii-entregara-5-524-kioskos-digitales.html>.
- ComSys. 2013. "©ComSys VSAT Report." Milwaukee, WI: ComSys. Available at [http://www.comsys.co.uk/wvr\\_main.htm](http://www.comsys.co.uk/wvr_main.htm).
- CSIS (Center for Strategic and International Studies). 2013. "The Economic Impact of Cybercrime and Cyber Espionage." Washington, DC: CSIS.
- Curello, C. et al. 2003. "Low-cost Multi-mission Broadband Communications Payload." U.S. Patent No.

- 6,628,919. 30. Sep. 2003. Washington, DC: U.S. Patent Office.
- Dorward, L. A. 2013. Universal Service Fund Study. Presentation to the 13th Global Symposium for Regulators. Warsaw, Poland.
- Embratel. Undated. "Embratel Star One-Uma Empresa Embratel." Available at [http://starone.com/br/en/internas/satellite\\_d1/](http://starone.com/br/en/internas/satellite_d1/).
- EMEC (European Marine Energy Centre Ltd.). 2009. "Guidelines for Reliability, Maintainability and Survivability of Marine Energy Conversion Systems." Orkney, United Kingdom: European Marine Energy Centre Ltd. Available at [www.emec.org.uk/guidelines-for-reliability-maintainability-and-survivability-of-marine-energy-conversion-systems/](http://www.emec.org.uk/guidelines-for-reliability-maintainability-and-survivability-of-marine-energy-conversion-systems/).
- Euroconsult. 2015. "Latin America: Top Region for New Satellite Capacity." Available at <http://www.satellitetoday.com/telecom/2015/05/15/latin-america-top-region-for-new-satellite-capacity/>.
- European Commission. 2015. "Digital Agenda for Europe: Broadband Business models." Brussels, Belgium: European Commission.
- Eutelsat. 2014. "Via Sat Brazil Books Full High Throughput Payload on EUTELSAT 3B Satellite for Broadband Services across Brazil." Press Release. Paris, France: Eutelsat.
- . 2015. "Eutelsat Communications Full Year 2013–2014 Results." Paris, France: Eutelsat.
- Executive Office of the President. 2015. "Community-Based Broadband Solution." Washington, DC: The White House.
- "Falling Satellite Insurance Premiums Put Market at Risk of Major Upheaval." 2012. *SpaceNews.com*. March.
- FCC (Federal Communications Commission). 2015. "Universal Service." Washington, DC: FCC.
- FITEL (Telecommunications Investment Fund). 2015. "TELCOR Ente Regulador." Managua, Nicaragua: FITEL.
- Fung, B. 2014. "What Washington can Learn from Colombia's Genius Plan to Lift Millions out of Poverty." *The Washington Post*. March 12, 2014.
- Garcia Zaballos, A. and R. Lopez-Rivas. 2012. "Socio-economic Impact of Broadband in Latin America and Caribbean Countries." IDB-TN-471. Washington, DC: Inter-American Development Bank.
- Government of Colombia. 2014. "MinTIC anuncia instalación de 253 nuevos puntos Vive Digital en el país." Bogota, Colombia: Ministry of Information and Communication Technology.
- Government of Peru. "Fiber Backbone." 2010a. Lima, Peru: Ministry of Transportation and Communication.
- . "Electric Transmission Lines." 2010b. Lima, Peru: Ministry of Energy and Mining.
- Government of Trinidad and Tobago. 2010. "Organizational Chart." Port of Spain, Trinidad and Tobago: TATT. Available at [https://tatt.org.tt/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core\\_Download&EntryId=734&PortalId=0&TabId=222](https://tatt.org.tt/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&EntryId=734&PortalId=0&TabId=222).
- . 2011. "2011 Population and Housing Census." Port of Spain, Trinidad and Tobago: Ministry of Planning and Sustainable Development.
- GSMA (Global System for Mobile Association). 2014. "The Mobile Economy 2014 – Latin America." London, United Kingdom: GSMA.
- Home Satellite. 2015. "Seattle Washington HughesNet High-speed Satellite Internet." Seattle, WA: Home Satellite.
- Hughes. 2015. "International Service Regions: Brazil." Germantown, MD: Hughes Network Systems LLC. Available at <http://www.hughes.com/international/hughesnet-servicesregions/brazil>.
- IDB (Inter-American Development Bank). 2013. "Program to Accelerate Educational Progress in Amazonas State (PADEAM)." Document BR-L1328. Washington, DC: IDB.
- iDirect. 2015. "iDirect Remote Commissioning Solution" Herdon, VA: iDirect. Available at <http://www.idirect.net/-/media/Files/Solution%20Overviews/Remote-Commissioning-Solutions-Overview.pdf>.
- IEA (International Energy Agency). 2011. *World Energy Outlook*. Paris, France: IEA. Inmarsat.
- Intelsat. 2015. "The Leading Provider of Satellite Services Worldwide." McLean, VA. Available at <http://www.intelsat.com>.



- \_\_\_\_\_. Undated. "Intelsat Annual Report." Washington, DC: Intelsat.
- IRENA (International Renewable Energy Agency). 2015. "Renewable Power Generation Costs in 2014." January 2015. Dubai, United Arab Emirates: IRENA. Available at <http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CATID=141&SubcatID=494>
- ITU (International Telecommunications Union). 2012. "Regulation of Global Broadband Satellite Communications." Geneva, Switzerland: ITU.
- \_\_\_\_\_. 2014. "ICT Statistics, Percentage of Individuals using the Internet." Geneva, Switzerland: ITU.
- \_\_\_\_\_. 2015. "Universal Service Funds." *ITU News 3*: June 2015. Geneva, Switzerland: ITU.
- ITU-R Radio Regulations. 2012. *Radio Regulations*. 2012 Edition. Contains the complete texts of the Radio Regulations as adopted by the World Radiocommunication Conference (Geneva, 1995) (WRC-95) subsequently revised and approved by the World Radiocommunication Conference (Geneva, 1997) (WRC-97), the World Radiocommunication Conference (Istanbul, 2000) (WRC-2000), the World Radiocommunication Conference (Geneva, 2003) (WRC-03), the World Radiocommunication Conference (Geneva, 2007) (WRC-07) and the World Radiocommunication Conference (Geneva, 2012) (WRC-12), including all Appendices, Resolutions, Recommendations and ITU-R Recommendations incorporated by reference.
- Kim, G. 2012. "How Much Does Fiber Really Cost?" Performant Networks.
- Lancaster, H. 2014 "Research Argentina 2014. Telecoms, IP Networks, Digital Media and Forecasts." April.
- Lepido, D. 2015. "Argentina Approves Breakup of Telecom Italia's Top Investor." *Bloomberg Business*. May 29, 2015.
- Market Update Kunstadter. 2014. Available at [http://worldspaceriskforum.com/2014/wp-content/uploads/2014/05/1\\_MARKET-UPDATE\\_KUNSTADTER.pdf](http://worldspaceriskforum.com/2014/wp-content/uploads/2014/05/1_MARKET-UPDATE_KUNSTADTER.pdf)
- Martinot, E., A. Cabraal, and S. Mathur. 2000. "World Bank Solar Home System Projects: Experiences and Lessons Learned 1993-2000." Washington, DC: World Bank.
- Martinot, E. and O. McDoom. 2000. "Promoting Energy Efficiency and Renewable Energy: GEF Climate Change Projects and Impacts." Washington, DC: Global Environment Facility (GEF).
- Mumssen, Y. et al. 2010. "Output-Based Aid: Lessons Learned and Best Practices." Washington, DC: World Bank.
- Nam, Changi, S. Kim, H. Lee, and B. Duan. 2009. Examining the Influencing Factors and the Most Efficient Point of Broadband Adoption in China [online]. *Journal of Research and Practice in Information Technology* 41(1): 25-38.
- NASA (National Aeronautics and Space Administration). 2008. "China Launches VENESAT-1 - Debut Bird for Venezuela." Washington, DC: NASA.
- National Geographic. 2011. "The World of Seven Billion." Available at <http://ngm.nationalgeographic.com/2011/03/age-of-man/map-interactive> .
- \_\_\_\_\_. 2015. "World Population Day." Country Maps. Available at <http://nationalgeographic.org/thisday/jul11/world-population-day/>.
- NYS Broadband. 2014. "Evaluating Global Growth in Broadband: The Need for Policy Leadership." Albany, NY: New York State Government.
- OECD (Organisation for Economic Co-Operation and Development). 2011. "National Broadband Plans." Paris, France: OECD.
- Ofcom. 2014. "2014 International Communications Market Report." Research Document. London, UK: Ofcom.
- Parliament of Australia. 2011. "Access to Broadband Services in Regional and Remote Areas." Canberra, Australia: Parliament of Australia. Available at [http://www.aph.gov.au/parliamentary\\_Business/Committees/House\\_of\\_Representatives\\_Committees?url=jcnbn/report2/chapter4.htm](http://www.aph.gov.au/parliamentary_Business/Committees/House_of_Representatives_Committees?url=jcnbn/report2/chapter4.htm).
- Peruvian State Portal. 2015. "Peru's Geography and Climate." Lima: Government of Peru.
- Population Density Maps. 2015. "Nicaragua Population Density Map and Administrative Borders." Available at <http://popdensitymap.ucoz.ru/>

- news/83\_population\_density\_administrative\_boundaries\_map\_of\_nicaragua/2015-03-23-99.
- PR Newswire. 2015. "El sistema satelital JUPITER, de Hughes, ayuda a cerrar la brecha digital en las zonas rurales de México." March 17 2015. Germantown, MD: PR Newswire.
- Reiche, K., A. Covarrubias, and E. Martinot. 2000. "Expanding Electricity Access to Remote Areas: Off-grid Rural Electrification in Developing Countries." *Fuel* 1(1.2): 1-4.
- Satcom Post. 2014 "Interview with Dave Rehbehn, Senior Director at Hughes Systems." July 31 2014. Available at <http://satcompost.com/dave-rehbehn-senior-director-at-hughes-systems/>.
- SIA (Satellite Industry Association). 2013. "State of the Satellite Industry Report." Washington DC: SIA.
- . 2014. "State of the Satellite Industry Report." Washington DC: SIA. Available at [http://www.sia.org/wp-content/uploads/2014/05/SIA\\_2014\\_SIR.pdf](http://www.sia.org/wp-content/uploads/2014/05/SIA_2014_SIR.pdf).
- SpaceNews. 2009. "Orbital Plans to Develop Cygnus-Based Crew Capsule." *SpaceNews.com*. September 11, 2009.
- . 2012. "Falling Satellite Insurance Premiums Put Market at Risk of Major Upheaval." *SpaceNews.com*. March 2, 2012.
- Spengler, S. 2015. "Is FSS Falling Short?" *SatCom-Post.com*. June 9, 2015.
- Tanner, J. 2015. "Satellite must look beyond its own horizons for growth: Intelsat." *TelecomAsia.net*. June 2, 2015.
- TATT (Telecommunications Authority of Trinidad and Tobago). 2014. "Annual Market Report. Telecommunications and Broadcasting Sectors." Port of Spain, Trinidad and Tobago: TATT.
- TELCOR (Nicaraguan Institute for Telecommunications and Posts). 2015. "¿Quiénes Somos?" Managua, Nicaragua: TELCOR.
- . 2015. "Directorio Institucional" Managua, Nicaragua: TELCOR. Available at <http://www.telcor.gob.ni/Directorio.asp>.
- Telebrás. 2014. "SECOP 2014: O papel da Telebras no Decreto nº 8.135/13 e a segurança da informação 30/05/2014." Rio de Janeiro, Brazil: Telebrás. Available at <http://docslide.com.br/documents/secop-2014-o-papel-da-telebras-no-decreto-no-813513-e-a-seguranca-da-informacao.html>.
- Telecompaper*. 2015. "Argentina Finalises Award of 4G Spectrum." June 15, 2015. Houten, Netherlands: *Telecompaper*.
- Telesat. 2015. "Satellite Services for Broadcast-Telecom-Corporate-Government-Satellite Services in North America-South America-Asia-Europe-Ka." Available at <https://www.telesat.com>.
- TELCOR (Nicaraguan Institute for Telecommunications and Posts). 2015. TELCOR Service Providers, Government of Nicaragua. Managua, Nicaragua: TELCOR.
- Thaicom. "Thaicom 4 (IPSTAR)." Bangkok, Thailand: Thaicom.
- The Economist Intelligence Unit. 2012. "Smart Policies to close the digital divide. Best practices from around the world." Available at <http://unpan1.un.org/intradoc/groups/public/documents/un-dpadm/unpan049753.pdf>.
- The State of California. 2008. "The California Broadband Task Force: Final Report." January. 2008. Sacramento, CA: The State of California.
- Trinidad and Tobago Population and Housing Census. 2011. Available at [www.tt.undp.org/content/trinidad\\_tobago/en/home/library/.../publication\\_1.html](http://www.tt.undp.org/content/trinidad_tobago/en/home/library/.../publication_1.html).
- TS2 Space. 2015. "Worldwide Satellite Communications Home Page." Warsaw, Poland: TS2.
- UNDESA (United Nations, Department of Economic and Social Affairs, Population Division). 2014. "2014 Revision of World Urbanization Prospects." New York, NY: UNDESA.
- UNDP (United Nations Development Programme). 2009. *Human Development Report 2009*. New York, NY: UNDP.
- Vanguardia*. 2013. "Kioscos Vive Digital serían un fracaso en Santander." November 23 2013.
- Vantage Point Solutions. 2015. "CAPEX Study." Mitchell, SD: Vantage Point Solutions. Available at <http://w-t-a.org/wp-content/uploads/2012/02/Vantage-Point-Study-7.13.15.pdf>.
- Woods, D. 2011. "Explaining the API Revolution to your CEO." *Forbes*. December 11, 2011.

World Bank. 2010. "Output-Based Aid Lessons Learned and Best Practices." Washington, DC: World Bank.

———. 2014. "2014 Data Rural Population." Washington, DC: World Bank. Available at [data.worldbank.org/indicator/SP.RUR.TOTL](http://data.worldbank.org/indicator/SP.RUR.TOTL).

———. 2015. *Doing Business Report*. Washington, DC: World Bank.

———. Undated. "Databank." Washington, DC: World Bank. Available at <http://databank.worldbank.org/data/home.aspx>.

World Bank, InfoDev, and the International Telecommunications Union. 2011. "ICT Regulation Toolkit: 2011." Washington, DC: World Bank.

World Teleport Association. 2015. "How to Buy Satellite Capacity. The Four Nines Project." New York, NY: World Teleport Association.

Yukon Government. 2015. "Rural Electrification and Telecommunications Program." Whitehorse, Yukon: Yukon Government.

## Websites/Databases

Agencia Bolivia Espacial. Available at <http://www.abe.bo/index.html>.

AR-SAT. Available at [www.arsat.com.ar/en/web/](http://www.arsat.com.ar/en/web/).

Centro de Mídias de Educação do Amazonas. Available at <http://www.centrodemídias.am.gov.br>.

Embratel. Available at <http://portal.embratel.com.br/embratel>.

Eutelsat. Available at <http://www.eutelsat.com>.

Hispasat, S.A. Available at <http://www.hispasat.com/en/>.

IBC Solar AG. Available at [www.abc-solar.de](http://www.abc-solar.de).

Inmarsat. Available at [www.inmarsat.com](http://www.inmarsat.com).

Intelsat, Ltd. Available at <http://www.intelsat.com>.

———. Intelsat Coverage Maps. Available at <http://www.intelsat.com/fleetmaps/>.

O3bNetwork. Official Webpage. 2015. <http://www.o3bnetworks.com>.

OSIPTEL. "Telecom Companies." Available at [https://www.osiptel.gov.pe/categoria/enlaces\\_empresas-operadoras](https://www.osiptel.gov.pe/categoria/enlaces_empresas-operadoras).

Satbeams. Available at <https://www.satbeams.com/satellites?norad=33414>

Sat Sig (Satellite Signals). Available at <http://www.satsig.net/ivsateurope.htm>.

SES. Available at [www.ses.com](http://www.ses.com).

Star One Official Page. Available at <http://www.starone.com.br/en/>.

YouTube. "Satellite Earth Station Antenna Maintenance, Installation Services, Communications Systems, Satcom." Provided by Digistat International Inc. Available at <https://www.youtube.com/watch?v=PrG-TGokRVc>.

ViaSat. "High-Capacity Satellite System: Transforming Satellite Broadband." Available at <https://www.viasat.com/products/high-capacity-satellites>.

VT iDirect. Available at <http://www.idirect.net/Company.aspx>.

## Laws

Government of Argentina. Law 27.078 "Ley Argentina Digital."

———. Decree 764/2000, enacted on 3 September 2000, Article 14.2.

———. Decree 2.426/2012, enacted on 13 December 2012.

Government of Nicaragua. Decree No. 84/2003, Creation of the Telecommunications Investment Fund (FITEL).

———. 5/2006, Constitution of the Telecommunications Investment Fund (FITEL).

Government of Peru. Legislative Decree No. 702 (1991).

Government of Trinidad and Tobago. 2001. The Telecommunications Act 2001. Part II (4).

## Interviews

Interview with ABS Ltd. November 18, 2014

Interview of Timothy Shea, APSTAR/ATP Satellite. March 17, 2015.

Telephone Interview with Luiz F.T. Perrone, OI S.A., Rio de Janeiro, Brazil, June 20, 2015.

Various Interviews during Satellite 2015 Conference in Washington, DC.



## Annex I: Satellite Operators in the LAC Region

Countries in the LAC region have been users of telecommunications satellite technologies from the early beginnings and have participated in the evolution of the industry. The following overview of satellite system operators active in the LAC region demonstrates how attractive a market it has become for major satellite service providers. The list does not include U.S. domestic satellite systems with coverage of LAC countries.

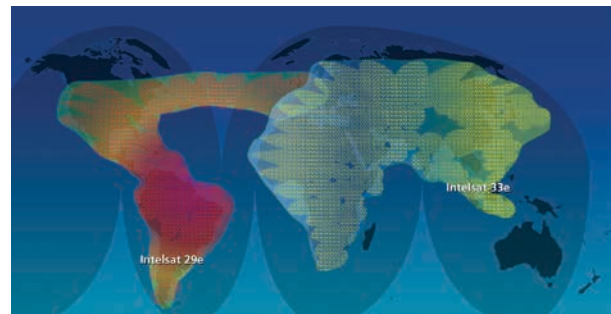
Although their major source of revenue has been TV services, satellite companies have recognized their commercial future in the field of broadband. With few exceptions, future satellites will include advanced payloads with specific characteristics supporting broadband services, either as feeder links to local hub stations, or for direct-to-end-user, consumer broadband. Most of these systems, if not available already, will be in place between now and 2017.

**Intelsat, S.A.**<sup>37</sup>



Intelsat, Ltd. is the operating successor to the former intergovernmental organization INTELSAT. Since privatization in 2001, it has also acquired the satellite fleet and customer base of the former PanAmSat telecommunications satellite company, and implemented a network of earth station hubs and cable facilities, offering global solutions for a large spectrum of services beyond the traditional

**FIGURE A.1** Intelsat Coverage of Epic Satellites



Source: Intelsat Epic<sup>NG</sup>, 2015.

satellite segment.<sup>38</sup> Intelsat has its corporate headquarters in Luxemburg, and its administrative headquarters in the state of Virginia. Its annual revenues are approximately US\$2.6 billion.

As of today, the company operates a fleet of 53 satellites, covering all regions of the world. Moreover, in 2014, the company announced it would be purchasing four new high-performance, high throughput Epic<sup>NG</sup> 702 MP satellites specifically designed for broadband applications. Two orbital positions have been identified for the deployment of the Epic satellites, with one offering coverage of the LAC region. Figure A1 shows the coverage

<sup>37</sup> See <http://www.intelsat.com/>.

<sup>38</sup> See <http://www.intelsat.com/wpcontent/uploads/2013/03/IntelsatONE.pdf>.

envisioned by Intelsat for the first two Epic satellites to be launched.

SES<sup>39</sup>

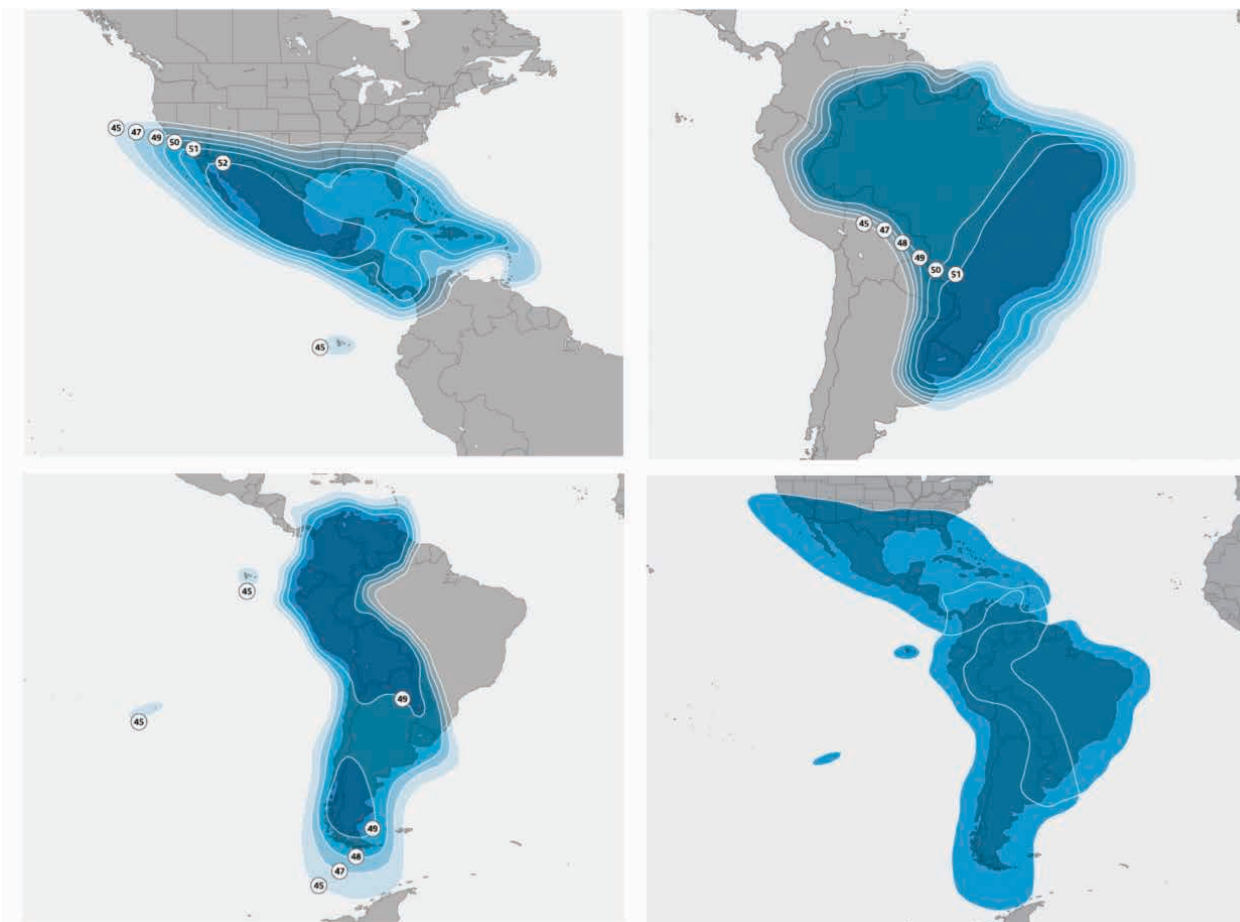


Based on revenue, SES is the second-largest telecommunications satellite operator, with annual revenues of approximately US\$1.9 billion. It originated in the European ASTRA direct-to-home satellite system, and it is based in Luxemburg. Since the late 1990s, SES has pursued an aggressive and successful expansion through acquisitions and penetration of all satellite-related service areas. Today, it operates a fleet of 52 satellites offering global coverage (Figure A.2).

With respect to broadband, SES operates a consumer, direct-to-end-user system in Europe. It has invested in the O3b MEO system designed to provide global broadband connectivity. In addition, SES recently announced its willingness to launch a high-powered satellite, SES-10, in 2016 to replace existing capacity over the LAC region and expand its presence there. This spacecraft will have dedicated high-power beam coverage for Mexico and Central America, and South America, as well as hemispheric coverage of the entire LAC region.

<sup>39</sup> See SES (2015). Available at from <http://www.ses.com>.

**FIGURE A.2 Coverage of SES-10**



Source: SES, 2015.



Eutelsat, S.A.<sup>40</sup>



Eutelsat, headquartered in France, began as an intergovernmental organization, focused originally on European markets. Since its privatization, it has become a global satellite operator. It reported 2014 revenues of approximately US\$1.8 billion.

Eutelsat's expansion included the acquisition of Satélites Mexicanos S.A. (Satmex), which added three satellites and a largely improved LAC presence to Eutelsat's business. It also purchased a substantial ownership share in Hispasat. Presently, Eutelsat operates 31 satellites. The latest addition to its fleet, Eutelsat 115 West B, was successfully launched in March 2015 and commenced service over the Americas in November 2015. Five more satellites are expected to be launched in 2015 and 2016. The fact that two of these new spacecraft are also to be deployed over the Western Hemisphere indicates Eutelsat's commitment to an increased focus on the LAC region.

With respect to satellite broadband, Eutelsat has pioneered the HTS with the launch of KA-SAT

in 2010. Of particular interest to broadband services in the LAC region may be the Eutelsat 65 West A satellite (Figure A.3), which was launched on March 9, 2016, by an Ariane rocket. Its coverage for broadband over the Americas is pictured below.

The abovementioned acquisition of Satmex by Eutelsat was completed in 2014, and the three operational Satmex satellites (Satmex-5, 6, and 8) were rebranded as Eutelsat satellites.

Telesat

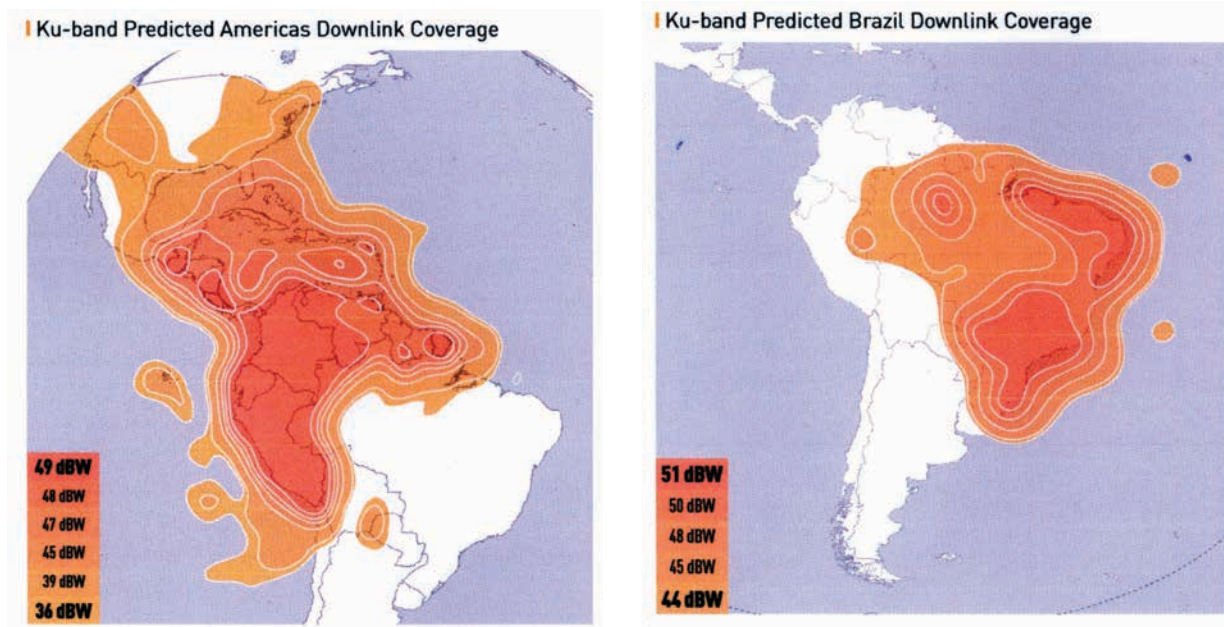


Telesat,<sup>41</sup> a Canadian satellite company, started out as the first operator of a domestic satellite system in the early 1970s, called the Anik satellites. They mostly served the dispersed population in the northern and northwestern parts of Canada.

<sup>40</sup> See Eutelsat (2015). Available at <http://www.eutelsat.com>.

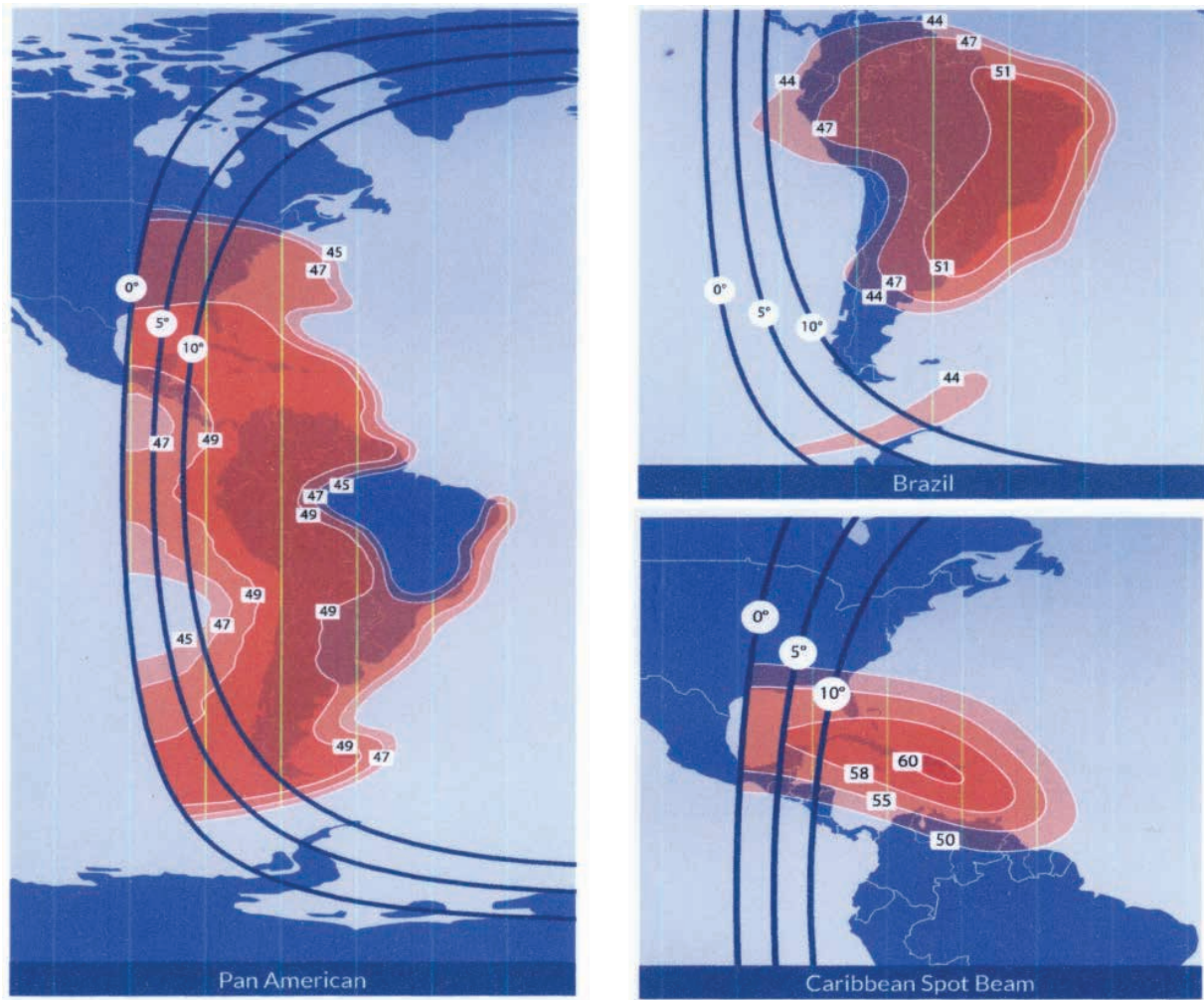
<sup>41</sup> See Telesat (2015). Available at <https://www.telesat.com>.

**FIGURE A.3** Eutelsat 65 West A Ku-band Predicted Coverage of LAC Region and Brazil



Source: Eutelsat, 2015.

**FIGURE A.4 Coverage of Telstar 12 Vantage Satellite**



Source: Telesat, 2015.

Telesat has a long history of serving sparsely populated areas.

Since its inception, through mergers and acquisitions, it greatly increased its scope of activities. Today, it is considered a global satellite systems operator. Besides its headquarters in Ottawa, Canada, it maintains offices in the United States, Brazil, the United Kingdom, and Singapore. It presently operates 15 satellites, and reported revenues of US\$923 million for 2014.

Of particular interest to the LAC region is Telstar 12 Vantage (Figure A.4). Launched in late 2015, it provides high power and high throughput

coverage over the Americas, with extensions across the Atlantic to Europe. The beam coverage relevant for the LAC region is shown in Figure A.4.

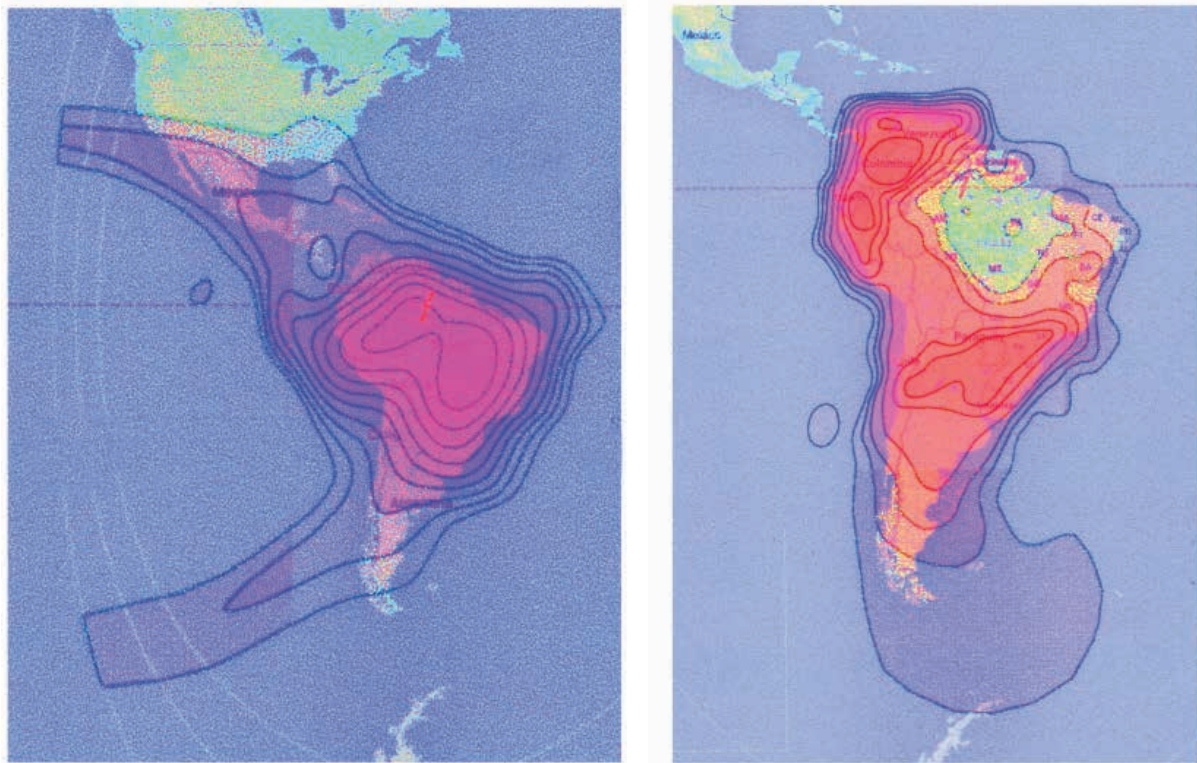
**Hispasat, S.A.**<sup>42</sup> 

Hispasat started in the early 1990s as a Spanish domestic satellite system for commercial and government/military applications. It quickly expanded

<sup>42</sup> See <http://www.hispasat.com/en/>.



**FIGURE A.5 Hispasat Amazonas-5 Satellite Coverage Example**



Source: ITSO.

its focus to Latin America, and, in cooperation with Brazilian companies, acquired and launched a series of satellites that serve the Americas, Europe, and parts of Africa.

Hispasat has undergone several changes in ownership, leading to a reduced government presence in the operation of the company. Eutelsat owns about one-third of Hispasat. Hispasat reported revenues of approximately US\$257 million for 2014. The Americas generated the largest share of the company's revenue—about 60 percent. Hispasat is headquartered in Spain, with subsidiaries and offices in Argentina, Brazil, Chile, Mexico, Peru, and Venezuela.

In the spring of 2014, Hispasat's newly launched Amazonas 4A satellite malfunctioned. The company reacted swiftly by ordering an improved and substantially larger replacement, Amazonas 5. This satellite will carry 24 Ku-band

transponders for Central and South America and 35 Ka-band beams for eight nations: Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Peru, and Venezuela.<sup>43</sup> It is expected to enter into service in 2017. Figure A.5 provides an overview of just two of the many beams this satellite will provide over the LAC region.

In May 2015, Hispasat announced an agreement with the Mexican telecommunications provider GlobalSat to provide broadband access to some 8,700 public facilities in rural and remote areas, demonstrating the company's recognition and expertise in the broadband arena.

<sup>43</sup> See <http://spacenews.com/42857ssl-takes-hispasat-contract-away-from-orbital-sciences/>.

## Embratel<sup>44</sup>



Embratel Participações, S.A. started as the international long distance carrier for Brazil. In the past two decades, it has evolved into a commercial full-service telecommunications company, with ownership of all types of transmission facilities and TV distribution services. In 2004, Teléfonos de México S.A. de C.V. (Telmex) acquired a controlling stake. For 2013, Embratel reported revenues of about US\$9 billion.

Presently, Embratel, through its subsidiary Star One, operates seven satellites with coverage of the LAC region. Two more satellites are under construction. One of them, Star One D 1, will be equipped with a broadband-optimized payload, capable of covering the LAC region. Its launch is planned for the first quarter of 2016.

Star One D 1 is a large satellite with 28 transponders in C-band, 24 transponders in Ku-band, and a large Ka-band HTS-type of payload. Final coverage maps have not been published. However, initial graphics available indicate a beam centered over Brazil in C-band, a Ku-band coverage of Mexico, Central America and the Caribbean, and additional Ku-band beams for Brazil, and all of the Andean countries.<sup>45</sup> This coverage is shown in Figure A.6.

## R-SAT, S.A.<sup>46</sup>



Empresa Argentina de Soluciones Satelitales (AR-SAT) emerged in 2007 from the former NahuelSat company that operated the first Latin American domestic satellite system, Nahuel-1, now decommissioned. ArSat is a state-owned enterprise with exclusive rights to use an orbital position allocated to Argentina. As such, AR-SAT launched the first communications satellite built in Argentina, AR-SAT-1 in October 2014. It is also chartered to implement Argentina's national connectivity plan, including, as a focal point, the improvement of broadband access across the

country and the region. AR-SAT-2 was launched on September 30, 2015. AR-SAT 3 was slated to be launched in December of 2015 but its construction was postponed. Because of the very recent launch of the first satellite, relevant data on the economics of the AR-SAT enterprise have not been published.

AR-SAT is of particular interest to broadband services because the AR-SAT 1 satellite provides coverage beyond Argentina's national boundaries, encompassing Chile, Uruguay, Paraguay and Southern Brazil. The procurement of the two additional satellites will provide additional and larger LAC coverage. However, final details of these deployments have not yet been published. Figure A.7, below, depicts the coverage of AR-SAT 1.

## Venesat<sup>47</sup>



The family of Venezuela's domestic satellites presently comprises two operational spacecraft, Simon Bolivar-1 and Miranda.<sup>48</sup> While the latter is a remote sensing satellite, the former provides telecommunications capabilities for Venezuela and neighboring regions. China Great Wall Industries manufactured both satellites. The Agency of the Ministry of Science, Technology and Innovation, Agencia Bolivariana para Actividades Espaciales (ABAE) operates them. The Simon Bolivar satellite became operational in late 2008.<sup>49</sup> It has a

<sup>44</sup> See <http://portal.embratel.com.br/embratel>, and STAR ONE C4. (n.d.). (2015). See also <http://www.starone.com.br/en/>.

<sup>45</sup> See [http://www.starone.com.br/en/internas/satelite\\_d1/](http://www.starone.com.br/en/internas/satelite_d1/)

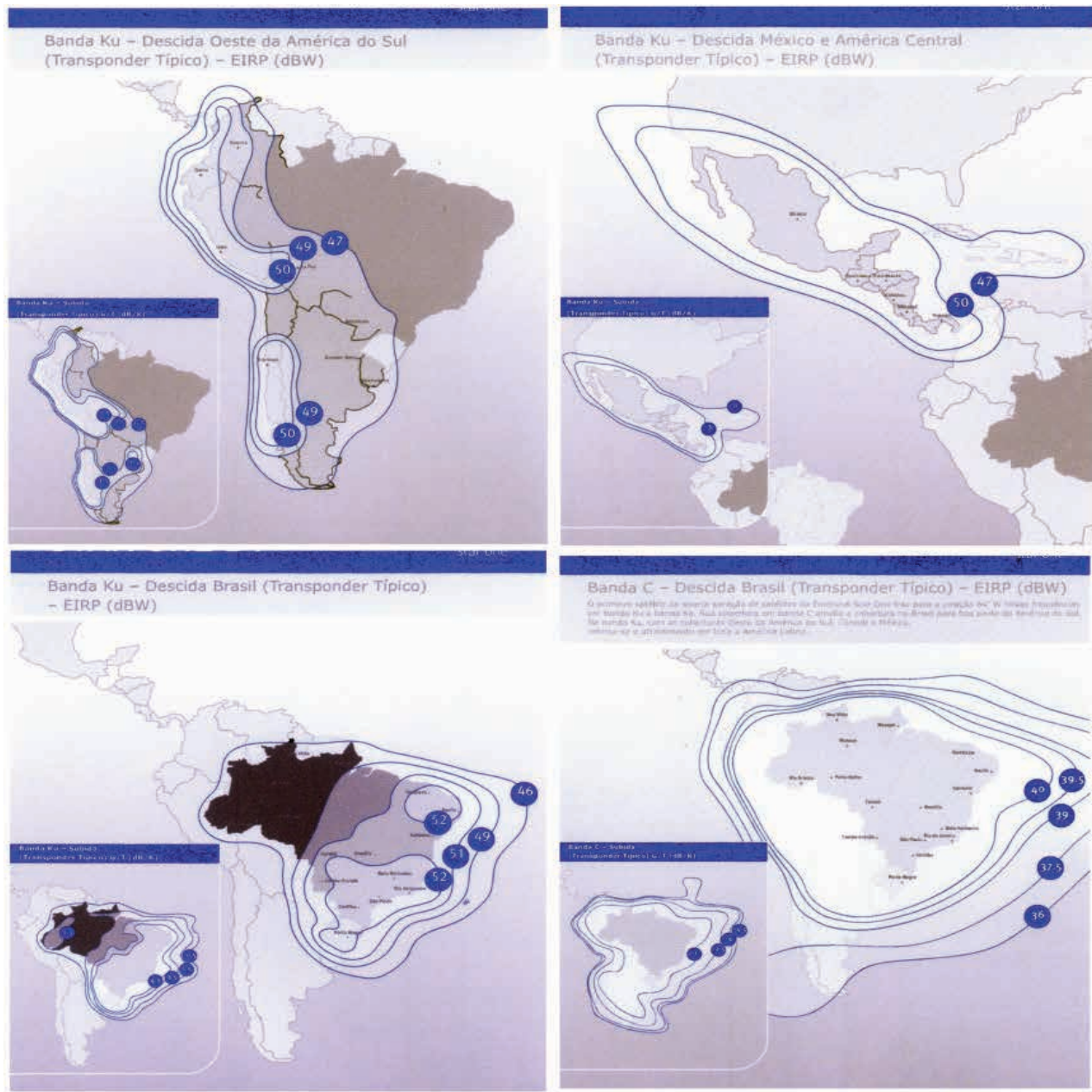
<sup>46</sup> See [http://www.bnamericas.com/companyprofile/en/Empresa\\_Argentina\\_de\\_Soluciones\\_Satelitales\\_S,A,-ARSAT](http://www.bnamericas.com/companyprofile/en/Empresa_Argentina_de_Soluciones_Satelitales_S,A,-ARSAT).

<sup>47</sup> See <http://www.nasaspaceflight.com/2008/10/china-launch-venesat/>.

<sup>48</sup> It should also be noted that there is a planned Simon Bolivar-2 telecommunications network. Based on an agreement between the Andean countries (Bolivia, Colombia, Ecuador, and Peru) and SES, the future satellite SES-10 will support this system. See the paragraph on SES above.

<sup>49</sup> In 2014, Venezuela signed an agreement with China for the construction of an additional satellite, named after

**FIGURE A.6 Coverage of Star One D 1 Satellite**



Source: Embratel, 2015.

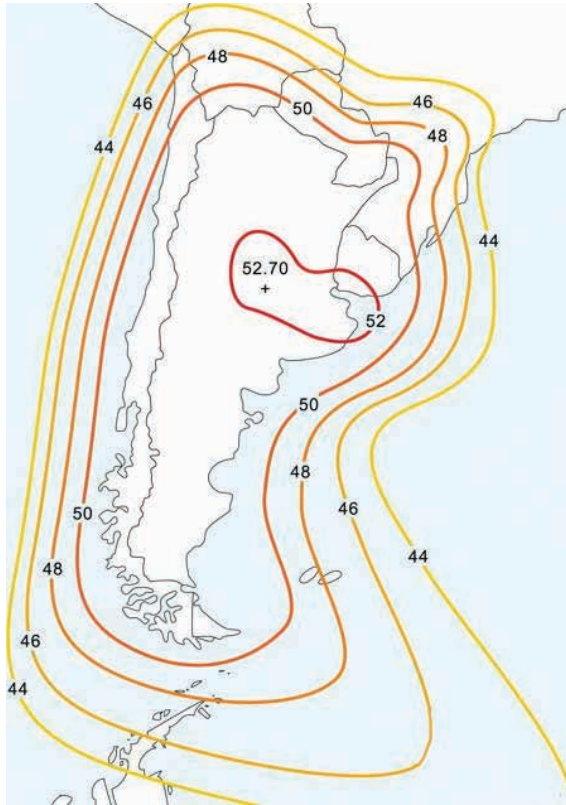
payload of 12 C-band, 14 Ku-band, and 2 Ka-band transponders.<sup>50</sup> Delivery costs for the system have been reported as US\$241 million, plus US\$165 million for the construction of two control facilities on the ground.

Antonio Jose de Sucre. It is also designed for earth observation and remote sensing.

<sup>50</sup> See Satbeams. Available at from <https://www.satbeams.com/satellites?norad=33414>.



**FIGURE A.7 AR-SAT 1 Coverage**



Source: AR-SAT, 2015.

### TKSat-1/Tupac Katari<sup>51</sup>



TKSat-1, built and launched by China, is operated under the authority of the Bolivian Space Agency (ABE). It went into service in March 2014. It has a payload of 2 C-band, 26 Ku-band, and 2 Ka-band transponders covering South America, the Andean region, and Bolivia with a higher power spot beam. A Chinese contractor is responsible for satellite and ground network control. The project costs are reported to be approximately US\$300 million.

### O3b Networks, Ltd.<sup>52</sup>



The O3b satellite network is a radical departure from the conventional systems based on

geostationary satellites. It employs a fleet of spacecraft in a medium earth orbit. Consequently, satellites do not virtually stand still for an observer on earth; rather, they rise over the horizon, travel along a visible arc, and then descend below the horizon. Given that a sufficient number of satellites are available, at least one must always be visible and accessible for a ground station.

O3b stands for “other 3 billion” the number of the earth’s inhabitants that, according to the company, cannot be served with conventional broadband media. Founded in 2007, O3b has since attracted powerful investors, including SES, Google, Liberty Global, and HSBC Bank. It has corporate headquarters in Jersey, United Kingdom, and operational headquarters in the Netherlands.

O3b began full commercial operations in September 2014, with a total current network throughput of 100 gigabits per second and 12 satellites in orbit, operating in Ka-band. The company expects 2015 revenues (the first full year of operations) to reach US\$100 million. Within three to four years, O3b plans for a total system throughput of 1 terrabits per second.<sup>53</sup>

For interruption-free service, O3b’s medium orbit configuration requires more than one antenna for each earth station site:

- One antenna tracking the satellite presently in use, until this satellite descends below the horizon;
- A second antenna that picks up the signal from the next satellite, before the previous satellite has disappeared from sight; and
- A third antenna as a spare, because the constant tracking operation is more prone to wear and tear than conventional nontracking or limited-tracking antenna systems.

<sup>51</sup> See <http://www.abe.bo/index.html>.

<sup>52</sup> See <http://www.o3bnetworks.com/>

<sup>53</sup> See <http://spacenews.com/ses-o3b-execs-view-proposed-new-mega-constellations-with-open-but-skeptical-minds/>.



The principal advantages of reduced latency and higher data throughput compared to conventional, geostationary satellite systems are offset by the increased complexity and cost of the earth station. Moreover, this complexity does not lend itself to deployment at small end-user sites, direct-to-home broadband, and others. Therefore, O3b earth stations with multiple tracking antennas would typically be serving regional or local broadband hubs, with last-mile connections provided by cable or microwave systems.

The O3b system coverage comprises practically the entire globe, except the northern and southernmost polar regions. Figure 1.6 in Chapter 1 depicts a coverage map of Ob3.

## Inmarsat



Inmarsat<sup>54</sup> PLC was established in 1999, following privatization from the former intergovernmental International Mobile Satellite Organization. It is headquartered in London, United Kingdom, and reported revenues of approximately US\$1.3 billion for 2014. It is a publicly traded company with

private equity companies and hedge funds holding a substantial share.

Although Inmarsat continues to follow its inherited focus as a mobile service provider, it has lately implemented a strategy to expand into the broadband segment, but still under the mobile services heading. This system is called Broadband Global Area Network (BGAN) using portable terminals. Typically, a BGAN terminal is connected to a laptop computer and provides Internet data access practically anywhere in the world, with a data speed of up to about 800kbps. The simplicity of operation, mobility, and flexibility of these small systems comes at a price substantially higher than other satellite broadband systems. Therefore, Inmarsat cannot presently be considered a truly cost-competitive option for broadband networks with a large number of consumers in the LAC region. Nevertheless, for commercial applications requiring the high mobility and flexibility of this service, and having fewer cost concerns, BGAN may be the service of choice in remote areas.

---

<sup>54</sup> See [www.inmarsat.com](http://www.inmarsat.com).

## Annex II: Renewable Energy Solutions for Broadband

The following sections provide an overview of alternative renewable energy sources with a focus on solar photovoltaic (PV) and wind power technology. They are addressed here, because these electric energy sources are of particular interest in rural and remote locations where conventional power is not technically or economically available.

The best solution for a given site depends on local site conditions and the electric power needs to operate the broadband access technology, including end-user equipment. Power requirements and quality (power fluctuation, predictability) of the renewable energy resource is location-dependent and varies from one site to another. Another site-specific factor to be considered is the availability and quality of an existing electrical grid. It is, therefore, essential to gain a good understanding of these factors before selecting a site-specific solution. However, considering the multitude of potential solutions for each project, a direct cost comparison of renewable with conventional energy sources is beyond the scope of this study.

**Solar PV technology** is based on the direct transformation of sunlight into electricity. Solar panels have been in commercial use since the 1960s to reliably power satellites (Figure A.8). Solar PV is the most mature, flexible, and scalable renewable energy technology, which can be used and installed almost anywhere for both smaller and larger applications. This makes solar PV technology an especially good choice for isolated rural farms and small population clusters. Solar PV technology has a long life span (warranties for solar PV panels are typically 25 years), requires no fuel, and produces no pollution or noise.

The main disadvantages include non-continuous operation (daylight only) and performance fluctuations due to local weather conditions (e.g., cloud cover). This drawback can be overcome by adding an electricity storage system (battery) to provide a constant source of electricity during nighttime and to smooth out power fluctuations.<sup>55</sup>

<sup>55</sup> See [www.abc-solar.de](http://www.abc-solar.de).

**FIGURE A.8** Examples of Sun-Powered VSAT Terminals<sup>a</sup>



Source: Ts2 Space, 2015.

<sup>a</sup> Retrieved June 15, 2015, from [http://www.ts2.pl/upload/Image/Satellite-equipment/Solar-Panels/solar\\_power\\_system\\_1.jpg](http://www.ts2.pl/upload/Image/Satellite-equipment/Solar-Panels/solar_power_system_1.jpg).

**Wind power** is also a time-tested alternative source of energy that has been used for thousands of years. The kinetic energy of the wind turns the rotor blades to drive a generator to produce electricity. Its main disadvantage is that the energy source is unpredictable. The amount of energy that can be created depends on generator capacity and the intensity of the wind resource (variable) at any given time.

**Other renewable energy sources** include micro-hydropower and biomass energy. As indicated before, considering location dependency, complexity, and ease of operation and maintenance, we do not consider these technologies a primary renewable energy source for telecom/broadband applications in locations without an existing electrical grid.

**Hybrid power solutions** combine more than one technology. They are typically used to compensate for the inherent power variations in any single

renewable energy source. Hybrid power solutions can reduce the inherent variability of renewable energy sources such as solar and wind to very low levels, thus providing a high-quality, low-cost solution.

In summary, solar, wind, and hybrid systems with battery backup for energy storage are the most cost-effective and reliable solutions to be considered for rural broadband sites.

The following pictures show two typical examples of proven and cost effective alternate energy solutions for sites that are either off-grid, or for locations where the existing source of electricity is unreliable.

The benefits of hybrid renewable energy solution are twofold:

- Lower network operating cost for mobile operators (cost of diesel fuel) and
- Lower environmental impact (reduction of carbon emissions, lower risk of health impact due to toxic fumes).

## Annex III: Consumer Broadband Equipment Providers active in LAC Region

The following is an overview of fixed-satellite service (FSS) providers in the consumer and VSAT broadband industry. Although some of these companies are also satellite operators, for the purposes of this study it is important to distinguish the two.

### Hughes Communications, An EchoStar Company

Hughes Communications (owned by EchoStar) is a vertically integrated company. It owns and operates satellites, builds entire ground segment infrastructure for antennas, operates and manages its own service, and provides system integration services.

Hughes provides its satellite-based communications services through its subsidiary, Hughes Network Systems (HNS), LLC. The services and products include managed network services, VSAT based broadband satellite technologies for a broad range of applications including broadband Internet access (small businesses, consumers), private corporate networks, public service applications (e.g., Internet kiosks, education/distance learning, health services, government, offices), and services for other service providers (e.g., cellular backhaul).

Hughes Jupiter system is a proprietary, managed network technology, which is comprised of an integrated gateway and remote terminals.<sup>56</sup> Figure A.9 is an example of a Hughes Jupiter gateway installed at a hub station. It was designed for use with high throughput satellites (HTS). A Jupiter gateway is a highly scalable platform supporting up to 10 Gbps of IP traffic and 100,000 plus consumer terminals in one or more networks. It can be operated with Ka-, Ku-, and C-band satellites. Current and planned deployments of Jupiter gateways outside the United States are located in Turkey, Malaysia, Mexico, and Russia.

In addition, Hughes' HN product is for IP broadband star and mesh networking applications for medium- to large-scale satellite broadband networks (enterprise, government, and consumer/small business solutions).

**FIGURE A.9** Hughes Jupiter Gateway Equipment



Source: *Satcom Post*, 2014.

Hughes owns and operates a 24x7 Network Operations Center (NOC) in Germantown, MD, and smaller but functionally similar NOCs in Brazil, Germany, and India.<sup>57</sup>

### Gilat Satellite Networks Ltd.



Gilat Satellite Networks Ltd. is both a vertically integrated system manufacturer of VSAT satellite ground station and related communications equipment (SkyEdge II platform including modems and VSAT hub baseband equipment), and a provider of managed network services (Gilat Peru and Gilat Colombia). As a system integrator, Gilat has provided turnkey installation services of VSAT networks. These include managed network services in Peru and Colombia, and cellular backhaul networks in rural areas (e.g., Alaska).

Gilat's services comprise VSAT and consumer broadband, backbone network services via satellite

<sup>56</sup> See <http://satcompost.com/dave-rehbehn-senior-director-at-hughes-systems/>.

<sup>57</sup> See <http://www.hughes.com/international/hughesnet-serviceregions/brazil>.

and fiber optic cable, virtual private networks and leased services, mobile satellite services, cellular backhaul, and voice.

## VT iDirect



VT iDirect's parent company is Vision Technologies Systems, Inc. (VT Systems), a subsidiary of Singapore Technologies Engineering Ltd (ST Engineering).<sup>58</sup>

iDirect is a manufacturer of VSAT satellite ground stations and related communications equipment (VSAT hubs, satellite modems/routers, network management software), and provides professionals with services planning, installation, and operation of VSAT networks.

iDirect has authorized and certified equipment distribution channels and provides installation services. iDirect operates a round the clock Technical Assistance Center to support satellite network operators and service providers.

iDirect has positioned their VSAT hub product (Direct Intelligent Platform™) as a modular entry product for VSAT network operators with special application needs. The iDirect product is IP centric and can be individually tailored to meet specific end-user needs.

## ViaSat, Inc.



ViaSat<sup>59</sup> is a vertically integrated company (owns and operates satellites, builds entire ground segment infrastructure using third party manufacturers,

operates and manages its own service) and provider of satellite services (Internet broadband for consumers, enterprises, and governments).

ViaSat is using its highly scalable SurfBeam-2 broadband networking platform to provide Internet broadband services (ViaSat's Excede) directly to consumers, small businesses, and via-resellers.

ViaSat operates three Ka-band satellites with coverage over North America. Another Ka-band HTS (ViaSat-2) is under constructions and expected to be launched in 2016. The coverage area of ViaSat-2 will include Central America, the Caribbean, and parts of northern South America.

## O3b



O3b is O3b is both a satellite operator and a broadband systems and service provider. The company's target customers appear to be fiber networks, mobile operators, and governments in emerging markets with a need to expand their terrestrial communications to remote areas and back up terrestrial segments (e.g. fiber, microwave).

The O3b system and service are currently in rollout using a 12-satellite constellation. Plans are in place to build and deploy additional satellites.<sup>60</sup>

<sup>58</sup> See <http://www.idirect.net/Company.aspx>.

<sup>59</sup> See [www.viasat.com](http://www.viasat.com).

<sup>60</sup> See <http://spaceflightnow.com/2014/12/29/o3b-networks-plans-satellite-fleet-expansion/>.





