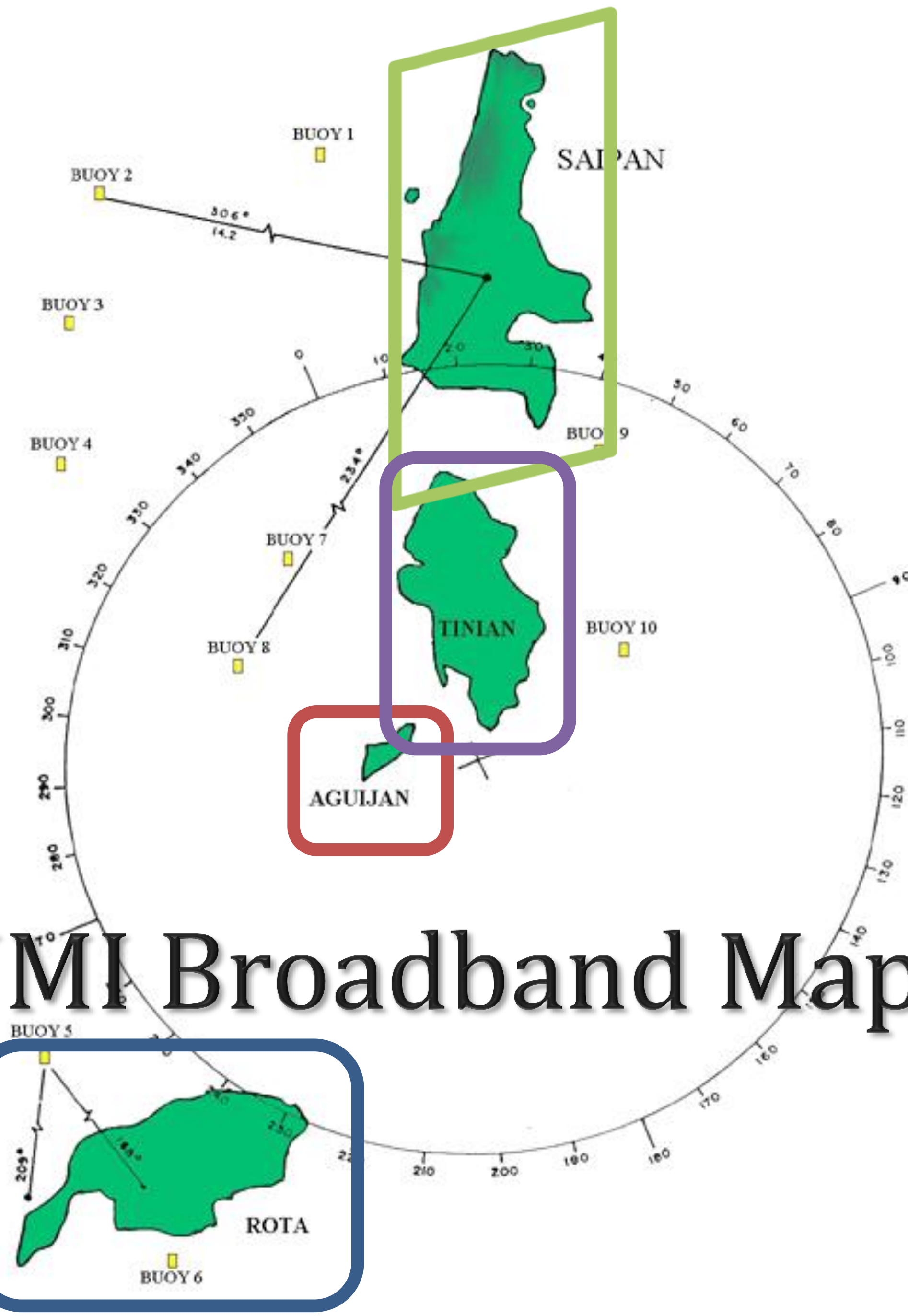
CNMI Broadband Mapping



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FOREWORD

As part of the State Broadband Initiative under the ARRA funding, this report depicts a comprehensive broadband map that covers Saipan, Tinian, and Rota.

The department contracted One Global Economy, Inc. in 2011 with a grant assistance from the National Telecommunications and Information Administration to assess the current state of broadband connectivity in the Commonwealth of the Northern Mariana Islands (CNMI) by determining how fast the connections are, what proportion of the population has access to broadband, what proportion of the population subscribes to broadband; identifying the most common barriers to broadband adoption and use; and creating a blueprint towards greater broadband usage.

This report of the digital blueprint of broadband in the CNMI provides results of the determinations, assessments, and provides for recommendations for the local governments of the three islands, the federal government, local NGOs, local Internet Service Providers, and the people of CNMI.

SIXTO K. IGISOMAR
Secretary

Final Report for the CNMI Department of Commerce
Prepared by One Global Economy
January 11, 2013

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Glossary

3G – A type of mobile Internet network mostly used by smartphones. It connects at speeds between 400-700 kilobits per second.

4G – A newer and faster type of Internet network than 3G mostly used by smartphones with speeds around 5-10 megabits per second.

ARRA – American Recovery and Reinvestment Act, also known as The Stimulus

Broadband – Refers to Internet speeds greater than 2 megabits per second or to any non-dial up type of transmission, like cable, fiber, or DSL.

Cable Internet – A method of Internet transmission that uses coaxial wires, which are also generally used to transmit television signals. The speed of transmission is usually around 10 megabits per second.

CDMA2000 – Code Division Multiple Access. CDMA2000 also known simply as CDMA , is the air interface standards aimed at 3G requirements.

Dial-Up – A method of Internet transmission that accesses the Internet though a phone line and a modem capable of only 56 kilobytes per second.

DSL – Digital Subscriber Line, a type of Internet transmission that sends digital data over phone networks.

EvDO – Evolution Data Only is a high-speed CDMA-based data system. It does not support voice, except for Voice over Internet Provider phones.

FCC – Federal Communications Commission, a federal commission that helps set standards and regulations for telecommunications issues.

Fiber (or Fiber to the Home) – A method of Internet transmission that uses fiber-optic cables from the middle-mile (see below) point to the user's residence.

GSM – Global System for Mobile Communications. Both HSPA and LTE are evolutions of GSM technology.

High Speed Internet – This refers to any type of Internet transmission with Internet download speeds greater than 4 megabits per second or to any non-dial up type of transmission, like cable, fiber, or DSL. When the mapping program started, in 2009, the definition was 768 kilobits per second.

HSPA – High Speed Packet Access. A higher-speed 3.5G evolution of GSM with speeds of 1-5.76 megabits per second download.

ISP –Internet Service Provider, the company from whom one gets Internet.

Last-Mile – The physical cables or wires from a landing station or service provider to a home, business, school or other place of use.

LTE – Long Term Evolution, a type of high-speed wireless service, very similar to 4G and primarily used on smartphones.

Microwave – A type of Internet transmission that utilizes radio frequencies and radio towers to wirelessly cover an area.

Middle-Mile – The physical cables, often undersea, that ISPs (see above) use to connect to the Internet and one another. For example, the middle-mile connections for CNMI refer to the cables between CNMI and Guam. Guam's middle-mile connections are the large undersea cables that go between the West Coast of the US to Guam and between Japan, Korea, China, and Guam.

NTIA – The National Telecommunications and Information Administration, a part of the Federal Department of Commerce

Satellite – A type of Internet transmission that transmits data via satellites. This type of transmission is mostly used in very small and remote areas because of its limited bandwidth and high cost.

Secured Wireless Connection – A home wireless network that is password protected, so only certain users can get online.

Served – A term used by the NTIA (see above) to denote an area where high-speed Internet access is available at any price.

Underserved – A term used by the NTIA (see above) to denote an area where only 200-768 kilobit per second Internet access is available at any price.

Unsecured Wireless Connection – A wireless network that does not require a password in order to access it.

Unserved – A term used by the NTIA (see above) to denote an area where the only Internet access available is less than 200 kilobits per second.

WiMAX – Worldwide Interoperability for Microwave Access. A telecom-based radio interface technology that provides wireless data in a variety of ways, from point-to-point links to full mobile cellular access.

Wireless Internet – A type of Internet transmission that uses 4G or LTE networks to get online. This is primarily used by mobile phones, netbooks, and cards that can be plugged into computers.

Introduction

The State Broadband Initiative (SBI) is a part of the American Recovery and Reinvestment Act (ARRA), which is more commonly referred to as the "Stimulus." The SBI's goal is to create a comprehensive broadband map that covers every state and territory in the United States. The uses of the map are manifold: as a tool for consumers, a centralized compilation of information for the federal and state governments to use in matters of regulation and public policy, and as a trove of data for think tanks and research institutions.

In addition to the mapping aspect of the SBI, there is also a planning component. The goal of the planning section is to create a comprehensive plan to understand the extent of broadband usage and ownership, barriers to adoption, and to create a plan to overcome these barriers and to boost broadband usage through work with nonprofits, local governmental agencies, and public policy advocacy.

One Global Economy was selected by the Commonwealth of the Northern Mariana Islands (CNMI) Department of Commerce to fulfill the broadband mapping grant that was awarded to them by the National Telecommunications and Information Administration (NTIA). One Global Economy is a global nonprofit community development organization whose goal it is to help low-income people gain greater access to and utility from broadband Internet connections.

One Global Economy's final deliverable is a comprehensive report that will assess the current state of broadband in CNMI by determining how fast the connections are, what proportion of the population has access to broadband, what proportion of the population *subscribes* to broadband; identifying the most common barriers to broadband adoption and use; and creating a blueprint towards greater broadband usage with recommendations for the local governments of the three most populated islands: Saipan, Rota, and Tinian, the federal government, local NGOs, local Internet service providers, and the people of CNMI.

The first step in this process was to draw upon the information and maps that the local telecom providers had to share with the entities undertaking the mapping project. These maps showed the approximate reach of where each telecom can offer service, what the maximum advertised upload and download speeds are, and what type of service they offer—DSL or cable, for example. These maps gave us a rough lay of the land and provided us with a good jumping off point for further research.

Using these maps information as a starting point, and drawing upon the knowledge of our local liaison, we were able to hold a series of 14 community meetings and focus groups. The main purpose of these meetings was to help us customize the NTIA's community broadband survey to make it locally relevant, culturally sensitive, and provide us with more detail about the experience of going online for the people of CNMI. For instance, knowing that many young people in CNMI get online at the Mobil Station in Garapan helps us get a better understanding of the role of unsecured wireless networks in public places in the online ecosystem of Saipan.

The next step was administering the survey. We hired JSB Consulting, a local survey firm whose surveyors could deliver the survey in CNMI's local language, Chamorro. They surveyed 1067 residents in person, 867 on Saipan and 100 each on Rota and Tinian. After compiling the results, One Global Economy analyzed them using multivariate regressions, bivariate correlations, and cross-tabulations.

One Global Economy researched the middle-mile[1] infrastructure of CNMI while the survey was being conducted. We learned that CNMI has only one cable connecting it to the outside world, which it does via Guam. This has many implications for commerce as

[1] Middle-mile infrastructure refers to the large fiber-optic cables that link large areas to one another. In the case of Guam, these cables are undersea, but in the case of most other places in the United States, they are overland or underground.

well as emergency connectedness. This lack of undersea fiber-optic cables makes CNMI one of the least connected places on Earth.

With this information and analysis in hand, One Global Economy shared the information with the residents of CNMI through another series of community meetings and focus groups to make sure that the information was accurate and to place outlying answers within a more understandable context.

The last stage is to compile all the information we have—the community feedback from the two sets of town hall meetings, the survey data and analysis, the initial maps, the middle-mile report, and the data gleaned from a speed test that we have been asking the residents of CNMI to take—and craft the final Blueprint for Greater Broadband Adoption.

Our hope is that the recommendations from this blueprint will help the CNMI bolster broadband adoption through several different avenues. The government of the CNMI can use this as a tool to lobby the federal government to allocate further funding to its middle-mile and adoption efforts. Internally, the CNMI government and the Commonwealth Utilities Commission can use this report as an impetus to monitor the local telecoms and to make sure that they are living up to the promises they made in their applications for stimulus funds. Local nonprofits and NGOs can use the blueprint to justify funding for computer education classes and further training. Businesses will be able to use our survey data as a justification for further investment in infrastructure and as an expansion of services. These are all just recommendations that no party is obligated to enact, but they are all openings to make broadband more available, affordable, and used by the people of CNMI.

Final Conclusions and Recommendations

CNMI has high rates of poverty and the closing of garment factories combined with the Japanese earthquake and tsunami of 2011 have contributed to high unemployment and emigration due to decline in all economic sectors. Against this backdrop of a shrinking population and economy, the high cost of Internet is prohibitive for many households. These households may turn to using Internet connections from nearby businesses or neighbors, perhaps without their consent. Yet reliance on a neighbor's broadband connection itself is likely not the primary cause of the low rates of broadband at home; rather, it is an effect of the high cost of Internet subscription and the inability of many residents to pay. Residents have a high desire for the Internet; they want to subscribe, they realize the benefits of the Internet, and they even have the hardware needed to access it. There is ample latent demand for broadband; however, the inability of the two ISPs to deliver high-speed Internet at affordable rates depresses residential broadband adoption. It is our opinion that additional competition for last mile connection will lower the cost to end users.

CNMI'S MIDDLE-MILE SITUATION AND OTHER SIMILAR CASES: Currently, CNMI and American Samoa are the only states or territories in the US served by a single, undersea cable. American Samoa is served by the American Samoa-Hawaii (ASH) Cable, which spans roughly 2500 miles from Hawaii to American Samoa. The ASH Cable was not a self-healing loop, as the CNMI cable is and did not have microwave backup, as is the case with CNMI. Given the extensive distance between American Samoa and Hawaii, the limited bandwidth of their cable, and the risk involved in having a non-self healing loop, ASH cable announced that it would be laying a new cable to Fiji.[2] It is our opinion that CNMI does not face the same middle-mile isolation

[2] Savali News *Two Samoas Meet.* 14 October 2012. http://www.savalinews.com/2012/10/14/two-samoas-meet/ Accessed 19 December 2012.

that prompted American Samoa to lay a new cable. Currently, the cables owned and operated by IT&E that link CNMI to Guam are ample for the territory's bandwidth needs. However, the issue remains that when all middle-mile connection points are owned and operated by a single entity, it creates a business chokepoint; the owner of the middle-mile connection has a monopoly over the market, and in order to gain a competitive advantage in last-mile delivery, it can charge downstream Internet service providers uncompetitive rates. It is our opinion that this type of middle-mile monopoly may have led to market inefficiencies in both American Samoa and CNMI, which is why we recommend that the CNMI PUC request local ISPs to disclose their total middle-mile capacity, the capacity they use for their own customers, the capacity they lease out to other companies, the price they charge for a leased line (i.e. DS3), and their cost of operating leased lines.

One Global Economy has met with schools in Guam and American Samoa that are currently taking advantage of new changes to the E-Rate program. In February 2010, the FCC voted to allow schools that receive connections through the E-Rate program to make those connections available to the communities around them. In both Guam and American Samoa, OGE encountered educational institutions that had made their E-Rate connections available via Wi-Fi to the community. What resulted was that community members would come at all times to check email, do homework, and communicate with relatives, while also utilizing other facilities the school had to offer, such as basketball courts and picnic tables. These schools had transformed into community hubs that were being used at all hours. We recommend that CNMI similarly create Wi-Fi networks accessible on school playgrounds and gathering areas in order to seed demand for and availability to access the Internet. It is our belief that if residents begin accessing the Internet outside the home, that they will value having a connection in their home and eventually purchase one.

Finally, OGE is using CNMI as an example for other states to emulate in terms of hardware adoption. The program to distribute laptops to school-aged children in CNMI has decreased barriers to Internet adoption and has led to very high rates of Internet use among households with children. These rates of usage surpass what would be expected in CNMI, given the household income level. As a result, OGE is recommending other low income territories like American Samoa should apply for and implement similar hardware disbursement programs in order to foster broadband use and adoption.

Further Government Grants: Presently, there are not any publicly available grants for CNMI to apply for in broadband adoption or middle-mile connectivity. The only funds that are currently available for CNMI are in the areas of professional development and training through the Department of the Interior's Technical Assistance Program (DoI TAP).[3] For example, staff members of the Department of Education expressed interest in how to better utilize e-learning programs; the Department of Education should therefore apply for funds to equip their educators with the tools they need to take advantage of e-learning technology. Other states such as Missouri, Alabama, and West Virginia among others have set up statewide E-Learning for Educators programs with federal funds. It is our recommendation that CNMI, in collaboration with a higher education institution such as University of Hawaii, try to set up a similar initiative targeting the schools in Tinian and Rota. Additionally, the DoI TAP could provide funds for the Department of Commerce in CNMI to engage in the professional development needed to continue to make updates to the national broadband map. This could include courses in ARC-GIS and targeted training from BroadMap on the use of its mapping tools developed specifically for CNMI.

For Representative Sablan's Office: The CNMI needs to secure funding to start any new programs aimed at boosting adoption. The logical starting point for this is the federal government. The CNMI's Congressman, Representative Sablan, should lobby for further

[3] http://www.grants.gov/search/search.do;jsessionid=L2L7QLCNfBLQSyCpCgs1J81GCvLV5tlpdHnQYqSkT81q0vp12yqL!-2129049045?oppId=203533&mode=VIEW

funding to be allocated to broadband adoption. The stimulus was very successful in increasing the middle-mile capacity to Saipan, but it should go further and improve the connections on Tinian and Rota, as well as funding broadband adoption efforts to help people get online.

IT&E's ARRA grant has allowed it to bring its DSL speeds up to the standards and prices of mainland US carriers. However, residential DSL lags behind higher speed technologies available on the mainland such as fiber to the home, high-speed cable, and LTE wireless. IT&E's stimulus grant has allowed the territory to catch up and eliminate the middle-mile bottleneck that had been curtailing speeds. Now, the territory must keep pace with the rest of the mainland as last-mile technologies continue to evolve.

CNMI DEPARTMENT OF COMMERCE: If additional investment in broadband infrastructure is to be made, and if the goal of universal access in the United States is to be realized, then that investment in CNMI should be made on the islands of Rota and Tinian. Residents there state that broadband is more important for them, yet they face greater availability barriers than elsewhere in CNMI. One Global Economy's maps of broadband infrastructure show several completely unserved areas that would benefit from last-mile infrastructure investment.

CNMI PUC: CNMI's biggest challenge moving forward may be how it fairly regulates telecommunications. There is presently only one undersea cable serving CNMI and it is owned by the ISP IT&E. IT&E connects the CNMI cable in Guam to a larger network of cables that allows for connections to the US mainland and East Asia. In its stimulus application, IT&E states:

IT&E's increase in capacity and redundancy along with the enhancements to the network infrastructure and billing & operational systems will provide consumers with additional choices not only in access equipment and connectivity but also with overall competition... [IT&E] commit[s] to offering wholesale access to the project facilities at reasonable *rates and terms. [IT&E] commit[s] to offering whole access to network components and services such as wavelength or fibers at reasonable rates and terms.*[4]

Through conversations with IT&E, MCV, Docomo, and PDS, One Global Economy has ascertained that IT&E's competitors are still under contract for bandwidth at rates that preceded IT&E's ARRA investments in infrastructure. It will be up to the ISPs and regulators to monitor the rates being charged going forward to ensure the IT&E is living up to the spirit of its ARRA grant and is charging reasonable rates and terms for the use of its middle-mile infrastructure that was federally funded.

CNMI PUC ACTION PLAN: It is our recommendation that the CNMI Public Utilities Commission review the competitiveness of the market for Internet services in one year's time to ensure all ISPs are benefitting from the federal investment in middle mile infrastructure in CNMI.

Given the latent demand and interest in broadband, it is our opinion that residents of CNMI would adopt broadband at much higher rates if costs could be reduced for the end-user, whether it is by increased last-mile competition or by increased middle-mile capacity.

NONPROFIT SECTOR: A nonprofit organization like the Ayuda Network should help teach computer and other information technology skills to the low-income and immigrant populations of CNMI. This can help them apply for and get better jobs, stay in touch with relatives, reduce human trafficking, and gain new skills. Hopefully, these types of programs can take root and receive funding from the CNMI government, the federal government, or other foundations.

[4] National Telecommunications and Information Agency – Broadband Infrastructure Application Submission to RUS (BIP) and NTIA (BTOP). Easygrants ID 1115 http://www2.ntia.doc.gov/files/grantees/ite_infrastructure_application_part1_2.pdf Accessed 10 October 2012

CNMI DEPARTMENT OF EDUCATION: It is our recommendation that every school's wireless network be made available 24 hours a day to all of the residents of CNMI. This will turn schools into community institutions. We have seen this work in American Samoa and we know that this can work in CNMI because all of the high school students in CNMI have laptops. E-Rate funds are available to fund this effort and we hope the CNMI Department of Education will pursue the acquisition of these funds to make broadband more available to all of the people of CNMI.

CNMI BROADBAND MAPPING TOWN HALL MEETING SUMMARY REPORT

May through July 2011

Prepared by

Thomas J. Camacho
CNMI Community Liaison
One Global Economy Corp.

August 29, 2011

Executive Summary

The following is the CNMI Broadband Mapping Town Hall meeting summary of 12 town hall meetings and two focus groups conducted by Mr. Thomas Camacho, One Global Economy's CNMI community liaison, between May and July of 2011 on the islands of Saipan, Rota, and Tinian.

This report examines the methodology and results of all the town hall meetings, including recommended changes to the draft Community Questionnaire Survey. It explores the attitudes of residents about broadband mapping, broadband use, and barriers to adoption.

Additionally, this report examines CNMI's middle-mile infrastructure and how it affects overall connectivity. This is a very important component because, in CNMI's case, it is a large impediment to greater broadband use and access. Its isolation and single fiber optic cable from Guam create a large hurdle to higher broadband speed and therefore greater adoption.

We found that the residents of CNMI are enthusiastic about the possibilities of broadband, but disappointed in the current speeds and prices available to them. Many complained about connection speeds that were slower than what they were told they had purchased (which are not that fast to begin with) for very high prices. In many cases, despite paying for a faster speed, users are still unable to stream videos and get the type of service that they are paying for. Slow speeds lead to decreased useability and less usage and adoption.

Digital literacy is a major problem in CNMI. Many people do not know what broadband is—whether it's a type of service like DSL or if it is something altogether different—let alone the speed of their connection. This lack of knowledge keeps many residents from being able to make informed decisions about technology in their own lives and prevents them from demanding more from their Internet providers or elected officials.

Background

CNMI lacks sufficient middle mile broadband infrastructure for its population. Large, fiber optic, undersea cables capable of carrying many gigabytes of data are necessary to provide the citizens of CNMI with high-speed broadband access. CNMI's only fiber optic cable comes from Guam. All of the major undersea cables from Asia, Japan, Hawaii or California route through Guam because of the large US military presence. This is a self-perpetuating cycle because Guam already has the necessary landing infrastructure and is thus more appealing for organizations to route through, which causes CNMI to rely solely upon its one cable to Guam for its Internet connection.

Further, this cable is privately owned by IT&E, a local telecom, which gives them a monopoly on the data that flows to and from CNMI. This allows IT&E to charge high rates from the other telecoms that operate in Saipan and the other islands of CNMI. However, IT&E does not own any of the cables that land in Guam, so other, larger telecoms charge IT&E high rates for the data transfers. This has a cascading effect where the consumers in CNMI have to pay a lot for service ($180 per month for an advertised 2.5Mbps) because of the several chokepoints the data must pass through.

Methodology

In advance of the first town hall meetings, One Global Economy hired Thomas Camacho as the local community liaison. The community liaison's role is to conduct the town hall meetings and help the Washington, DC-based staff meet with local stakeholders and better understand the culture and state of broadband in CNMI. Daniel Calarco and Colin Richardson of One Global Economy hosted the first town hall meeting to show Mr.

Camacho the model upon which the subsequent town hall meetings that he conducted should be based.

Attendees were provided with One Global Economy's goals, partners, program and outcomes flyer. The presentation starts with a 30-45 minute Power Point presentation describing the intent, process, and reasons behind the CNMI Broadband Mapping program, the role of the CNMI Community Liaison, and who One Global Economy is.

The last part of the meetings was devoted to reviewing the draft of Community Questionnaire. The OGE community liaison noted the comments and forwarded them to One Global Economy for consideration.

The most successful method of advertising the town halls was through word of mouth via friends, neighbors, co-workers and associates. One Global Economy and its liaison used their contacts in the CNMI government, NGOs, and local media to promote the town hall. One Global Economy emailed promotional public service announcements to several radio stations, two major newspaper publishers, a cable news channel, and the free advertisement channel on Cablevision. One Global Economy (OGE) also sent mass email invitations to numerous individuals, agencies, offices and non-profit organizations. Additionally, OGE sent email invitations to all high school administrators as well as community anchor institutions such as police departments, public and school libraries, fire departments, other emergency personnel, and junior and high schools. Mr. Camacho made follow-up telephone calls to remind many of these organizations. OGE developed an invitation to attend the CNMI Broadband Mapping Town Hall Meetings as a flyer and distributed it to stores and posted them in public buildings. Mr. Camacho used his membership in the NGO umbrella organization Ayuda Network, Inc. to forward all scheduled town hall meetings to each of its 30 members. He also promoted the town hall meetings when he attended meetings with community-based disability related organizations, such as CNMI Council on Developmental Disabilities, State Rehabilitation Council, and the State Independent Living Council.

One Global Economy coordinated and organized two CNMI Broadband Mapping Focus Groups with the CNMI Department of Commerce staff and management and the staff and board of directors of the Ayuda Network, Inc.

Summary of Findings:

The most successful methods were mass emailing and the public service announcements. Posting and disseminating fliers was less successful and somewhat more difficult and painstaking to do since it required driving around the entire island.

Collaboration with local government was a necessary and successful component of this project throughout the town hall process. One Global Economy received support and assistance from the public schools, the mayor's office, the governor's office, and especially the Department of Commerce. These collaborators allowed One Global Economy to use their facilities, conference rooms, public gathering areas.

The most successful outcomes of the town hall meetings were educating members of the community about the methods and purposes of the broadband mapping project and getting input from the community on the survey to make it more relevant. Honing the survey through community input will improve the data One Global Economy will get from the survey once it's administered. The PowerPoint presentation and handout materials were very effective at explaining what the broadband mapping project is, who's funding it, and what the desired outcomes are.

Most of the town hall meetings were held at public school cafeterias with the other meetings held at social/youth centers, public hall facilities and government conference rooms. The two focus groups were held at the Department of Commerce Conference room and the Ayuda Network, Inc. conference room, respectively.

Based on the sign up list for each town hall meeting and focus group, in attendance were: public health officials, labor officials, residents, school administrators, teachers, former legislators, a judge, directors, college faculty, juvenile justice personnel, mental health administrators, homeless shelter staff, disability advocates, members of the mayor's staff, physicians, computer store owners, IT personnel, school administrators, columnists, youth services staff, private company owners, court staff, utility staff, broadband subscribers, high school students, retirees, US congressional staff, and college students amongst others.

Community Questionnaire Survey Comments & Suggestions:

Most of the suggestions and edits to the survey that we received centered on clearing up racial categories in the demographic section. These included adding sub-categories for Asian and Pacific Islander, adding Native Hawaiian and amending one of the Chamorro classifications. There were also helpful suggestions about the ways people in CNMI connect to broadband. These suggestions included adding tablets and iPads as devices that people use, tethering mifi as a way to connect, and restaurants as a place where free Wi-Fi is used to get online. Additionally, parts of the survey were simplified to make knowing one's speed easier by tying the speeds to plans that are offered by the local telecoms.

Comments and suggestions from Town hall-village meetings:

<u>Island of Tinian</u>

- **Access:**

Access to broadband in Tinian is a problem. IT&E is the only provider, so there is no competition whatsoever. Residents reported that they want high speed broadband in the high schools, particularly because slow broadband doesn't allow students to use the Internet to its fullest in one class period's time. Further, there are certain villages on Tinian that have no broadband service available at all. There are chronic service disruptions because of the insufficient bandwidth for the entire island.

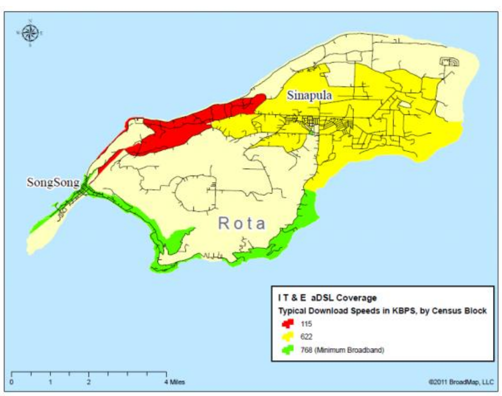
- **Cost:**

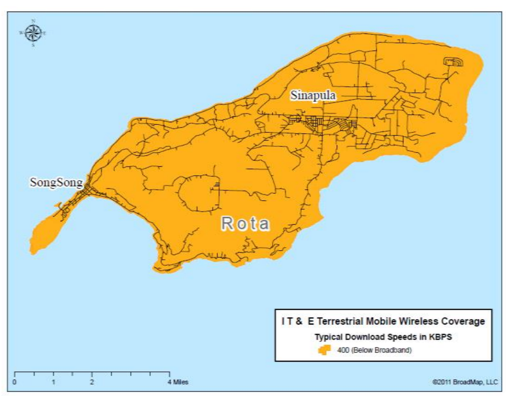
Attendees noted that CNMI—and Tinian in particular—was one of the most expensive places to get broadband in America. This, combined with the slow speeds that residents receive constitutes a significant barrier to broadband adoption. Residents have to pay nearly $100 for 1Mbps (advertised) because IT&E is the only provider that services Tinian.

- **Internet Speed:**

Residents of Tinian say that their Internet connection is too slow. It is too slow to watch YouTube videos and most people on CNMI can't do things online that many other Americans take for granted. All of Tinian is underserved by speed according to the NTIA definition, which confirms what the residents suspect.

<u>Island of Rota</u>





- **Education:**

Residents of Rota know very little about the broadband mapping project and a major goal is to educate them about that. Moreover, digital literacy on Rota is low and some residents would benefit greatly from further computer and technological training.

- **Access:**

Rota is made up of rural communities who have poor access—if any—to broadband. Access is particularly important to a place as isolated as Rota, which is about 75 miles from Saipan, because this community could greatly benefit from online education, medical advice, and greater access to information in general. There is a lack of competition and that is reflected in the available services.

- **Cost:**

Broadband is very costly on Rota. As in Tinian, IT&E is the only provider and residents have to pay close to $100 for 1 Mbps and $180 for 2.5 Mbps if they want speeds that qualify as broadband.

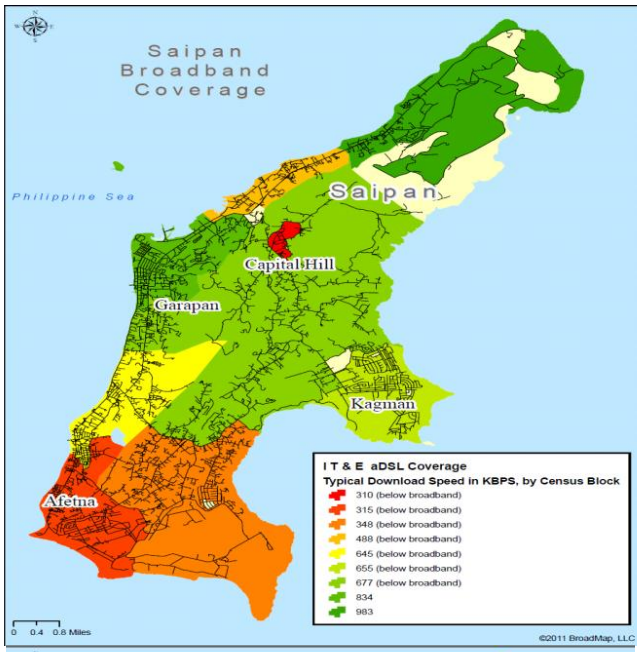
- **Speed:**

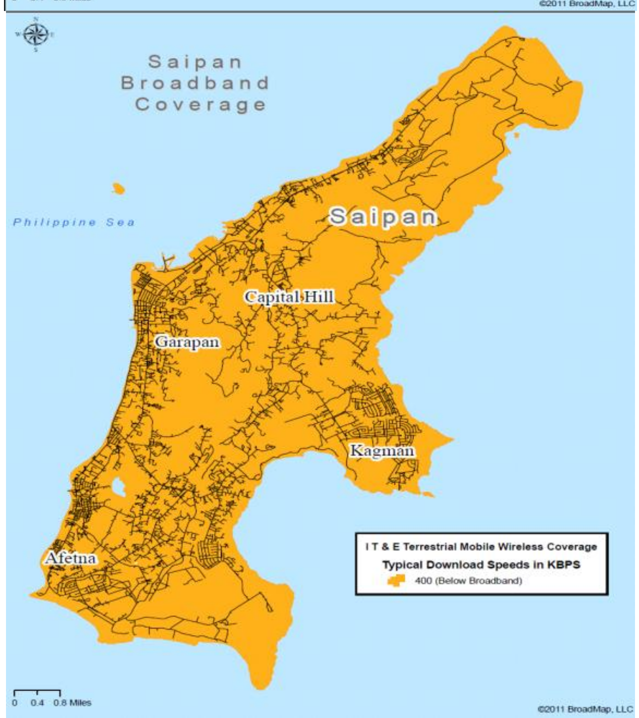
Rota has three tiers of typical download speed. In Song Song and along the southern coast residents can access broadband at 768 kbps, which is the minimum definition of broadband according to the NTIA. In the east, around Sinapula, the typical download speed is 633 kbps, just under the threshold to be considered broadband. Along the northeast coast, between Song Song and Snapula, the typical speed is 115 kbps, making it an unserved area. Many residents rely on air cards because of the lack of access to wired services, but the air cards offer only slow service, which is susceptible to disruption from rain and storms, which are common on Rota.

- **Service:**

Residents want to know how ARRA funds, particularly those steered to IT&E, will impact their lives.

Island of Saipan





- **Education:**

The bulk of the town hall meetings were held on Saipan, the most populous island in the Mariana Islands. Most residents think that broadband is a necessary tool today to stay up-to-date on current events and connected to the wider world, but there is still a sizeable population that does not even know what it is. It was common to hear attendees at town hall meetings ask what “broadband” is; with that question they were not just asking what speed was necessary to fulfill the definition of broadband, they were asking about the term itself. Many didn’t know if it was a type of technology—like DSL or cable—or something else entirely. This was especially true for seniors. One elderly woman asked, “What does broadband do, to whom is it important and useful, and how?” This was a typical question that was asked at most of the town hall meetings. Town hall attendees also wanted to learn more about the different Internet service providers and which agency, if any, regulates them. Town hall participants were both excited for and curious about the mapping project. Many hope that it will lead to faster and more affordable broadband, which all attendees desired.

- **Access Problems/Concerns:**

There are two necessary components to wide scale broadband access and use: hardware such as computers, iPads, etc. and last-mile bandwidth. CNMI's residents have plenty of hardware because all high school students have laptops through a program with CNMI schools. This alone solves the usually difficult and large problem of hardware acquisition. Despite this, most Internet connections in Saipan—and CNMI as a whole—are slow and experience disruptions because of the lack of bandwidth to the entire island. There is only one fiber optic cable that goes into Saipan and it is privately owned by IT&E and comes from Guam. This middle-mile cable has a capacity of 10 Gbps, but IT&E is currently only capable of using an estimated 1.1 Gbps. This is simply an insufficient amount of bandwidth for an island of Saipan's population. MCV, the cable company in CNMI, has only 40 Mbps *total* for its 2000 subscribers, so it is almost always at full capacity and users can almost never connect at 1 Mbps. Further, there are homes without electricity or with a limited ability to afford it that have no access to broadband. This is true for residential and business connections.

- **Cost:**

Cost is a major impediment to wide-scale access and usage of broadband. Many residents of CNMI voiced or concurred with the theory that IT&E's monopoly of the fiber optic cable into CNMI from Guam was responsible for the high cost of broadband. They believe that this monopoly allows IT&E and MCV to offer sub-par service because the residents have no other choices, and that more competition would bring faster service and lower prices.

- **Speed:**

Slow upload and download speeds are the biggest hindrance to effective broadband use in CNMI. Attendees to the town hall meetings were uniformly frustrated and knew that the speeds they get are slower than they should be. Still, many haven't experienced faster speeds elsewhere and do not fully know what they are missing. Despite the widespread lack of experience online, residents agree that speed is particularly important in schools because students only have 45 minutes in each class and that time cannot be wasted waiting for pages to load. The slow speeds still prohibit many online activities that many Americans take for granted and make for an unsatisfactory user experience. One resident complained that he had to wake up at 3 am to go online because that was one of the few times when island-wide use is low and the speeds are better.


EXIT
SALBAHE'

The Northern Islands

The government in CNMI is trying to resettle the islands of Pagan, Alamagan, and Agrigan, whose residents were forced to evacuate the island because of a major tropical storm. Currently, there are about 9 people on Pagan and 3 in Alamagan. There are hundreds of people who want to return to these islands, but it is not possible yet because there are no schools, health clinics, and other basic institutions that are necessary for a population of any size. The Northern Islands' Mayor's Office is trying to economically develop these islands but there is no running water, phone lines or electricity aside from private generators. The only method of communication with the outside world from these islands is via sideband radios. Broadband Internet access would be extremely useful in places as isolated as these islands, but the basic infrastructure needs must be met before there can be any realistic expectation of Internet access.

Demographics

With respect to demographics, individuals in attendance were a mix of ages from as young as 18 years old through people in their 60s.

Conclusions:

First and foremost, the town hall meetings showed that a sizeable number of people in all three main islands of CNMI (Saipan, Tinian, and Rota) were largely uninformed about what broadband is and what it can be used for. Additionally, most members of the community did not know about the broadband mapping project that is underway in CNMI. There was a common frustration among most end users at the slow speeds, regular disruption of services, and the high costs of service. These frustrations were felt by individual subscribers and businesses alike. Residents said they would make more and better use of the Internet if they had faster connections and could pay less.

Attendees think that to improve the current situation the CNMI government will have to re-examine IT&E's exclusive ownership rights of the one and only fiber optic submarine cable to CNMI from Guam. This monopoly requires any other provider to pay large fees to use the same—and very limited—bandwidth available, the costs of which are then passed on to the customers. Residents want the fiber cables to extend all the way to the home. A lack of community education on the meaning, uses, and benefits of broadband are a major impediment to broadband adoption and even community participation in the CNMI mapping project.

Cost is a major barrier to greater adoption. Attendees of all the town hall meetings are hoping for a decrease in the rates they have to pay for Internet access. There is optimism that there will be changes to the Universal Service Funds regulations that will allow the use of money from the USF to pay for increased broadband Internet access. This is most acutely felt on the remote islands of Tinian and Rota, where there is only one broadband Internet provider. This is part of the explanation of why Rota and Tinian are poorly served compared to Saipan.

There is a desire amongst residents in CNMI for greater choices in the broadband market. They hope that Guam-based providers will invest in CNMI and lay another fiber optic cable to the island or at least offer services and cause a reduction in prices with greater competition. There is currently interest from a new provider, but they are waiting for a license or permit approval from the Commonwealth Public Utility Commission.

In closing, while CNMI residents have had Internet access for several years they have not been able to realize the full array of benefits that connectivity offers because of a lack of access to broadband speeds, high prices for any connection, and a lack of knowledge about the benefits and how to make use of broadband. The lack of access at the necessary speeds to meet the minimum definition of broadband stymies many. The residents of CNMI know that broadband has already increased access to information and revolutionized the way people interact with each other, but they are just now becoming fully aware of how broadband can play a critical role in improving their quality of life and they want access to it.

Community Survey

METHODOLOGY

Based on community input from a series of town hall meetings conducted in local areas throughout the Northern Marianas Islands (CNMI), One Global Economy created a finalized survey aimed at understanding factors that influence broadband access and use. In order to carry out the survey, One Global Economy contracted with JSB Consulting, a locally based survey firm which has collected data in CNMI for the US Census and for various local government branches. Surveys were conducted in person, in respondents' homes, by local surveyors, who asked respondents questions in the respondents' preferred language.

Respondents were selected to be representative of the population of CNMI, which consists of three main islands: Saipan, Tinian, and Rota. JSB Consulting (JSBC), as required under its contract with One Global Economy, selected a total of 867 Household (respondents) on Saipan, 100 on Tinian, and 100 on Rota, for grand total of1067 respondents. Although the task order under the contract calls for 1000 respondents, JSBC selected and additional 67 household (respondents) for Saipan to ensure that all areas on the island of Saipan are covered/represented. Selected sample dwellings that appeared vacant (upon survey period) were substituted with another occupied dwelling unit from the listing.

On the island of Saipan, JSBC used a stratified sampling approach to ensure that respondents were selected to proportionally represent the geographic distribution of the island's population. JSBC drew the samples by using the geographic boundaries assignments areas (AAs) and the block numbers within the AAs. The AAs and block numbers are the geographic numbers assigned by the U.S. Census Bureau and used in Censuses and Survey operations in the CNMI. The Central Statistics Division has retained and maintained the same geographic structure since its inception. On Saipan a total of 328 assignment areas (AAs) out of 497 AAs were drawn. From these selected AAs, JSBC then randomly selected specific dwelling units in accordance with the population of those AAs. More dwelling units were drawn from AAs with larger populations, and fewer were drawn from those with smaller populations. Once a dwelling unit was drawn, it was then assigned to the field staff for enumeration.

On Rota and Tinian where only 100 sample subjects on each island were needed, the collections methodology was a straight forward random sample approach was used. Since there are only a little over 600 hundred dwelling units on each Island, approximately 1 out of every 6 dwelling units was selected for inclusion in the sample. Tinian and Rota each have only two main villages; on each island, 50 respondents from these main villages were selected for the sample. The collection method used was the "keep right" approach,[5] using the AA and block maps. This approach was used to ensure that the field staff does not cross over a certain boundary to cause a problem or any confusion in the process.

With each survey, surveyors noted the location of the respondent's dwelling according to JSBC's designated geographic areas. While respondents were also asked to say where they lived, this official designation allows for more uniform aggregation of the data according to legal boundaries.

[5] The "Keep Right" approach is one is working on a block (the smallest geographic unit in data collection boundary) the enumerator/survey takers keep themselves on the right side of the road/boundary from any designated starting point. This prevents any selected house from being missed or going out of the designated boundary.

Once the data was collected and entered into a database, One Global Economy analyzed the data using SPSS. One Global Economy performed logistic and linear multivariate regression analyses, bivariate correlations, and cross-tabulations to better understand the patterns in the data and the relationships between key variables. Cross-tabulations and bivariate correlations show the overall distribution of the population in relation to certain factors, and also the general relationship between different variables. Multivariate regression analyses were also used to determine the relationships between relevant variables after controlling for (holding constant) other related factors, and also to assess the statistical significance of these relationships. For example, simple correlations may show that additional years of education and higher income are each directly correlated with broadband adoption in the home. However, since more education and higher income are themselves often related, it is difficult to tell whether it is income or education that plays a more significant role in determining whether a household adopts broadband. A multivariate regression analysis can show whether income or education has a larger and more significant impact on broadband adoption.

Demographics

CNMI is a territory with a population in flux. It currently is ranks last in the world in population growth (-4%) and last in the world in net migration (-57.46 migrants per 1000 inhabitants).[6] In 2000, CNMI had a population of approximately 70,000 residents.[7] The 2010 Census, however, put the population closer to 54,000.[8] As a result of this significant population outflow, follow-up studies would be needed to accurately assess the

[6] CIA World Fact Book, Northern Marianas Islands. https://www.cia.gov/library/publications/the-world-factbook/geos/cq.html Accessed 10 January 2012.

[7] Census Bureau Release Census 2000 Population Counts for the Commonwealth of the Northern Mariana Islands http://www.census.gov/newsroom/releases/archives/census_2000/cb01-cn173.html Accessed 10 January 2012.

[8] Census Bureau http://commerce.gov.mp/wp-content/uploads/2012/12/2010-Census-Demographics-Profile-Summary-by-District.pdf Accessed 12/19/12

relationship between broadband adoption and the rapidly shifting demographics of CNMI.

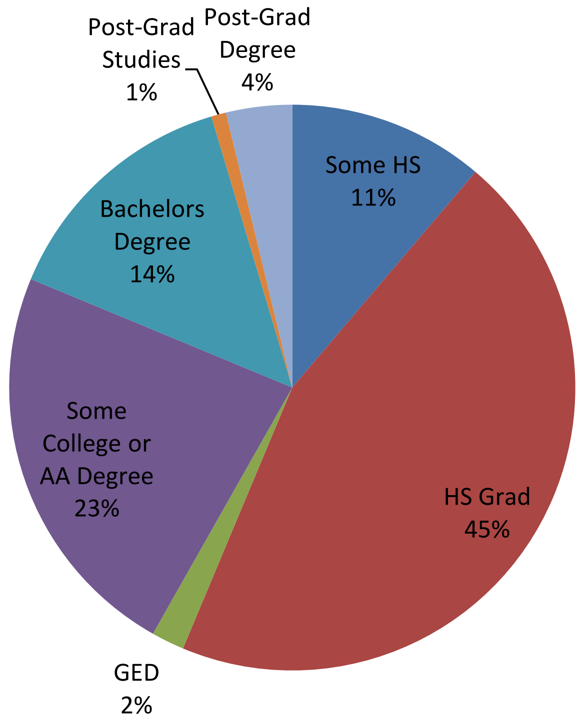
Currently, nearly all residents of CNMI inhabit the three southern islands of Saipan, Tinian, and Rota. The northern islands were once inhabited but have been evacuated due to seismic and volcanic activity.[9] 1067 surveys were conducted in total, 867 with residents of Saipan, 100 with residents of Tinian, and 100 with residents of Rota. While surveyors identified potential respondents based on their residence, survey respondents were somewhat more likely to be male (53%) than female (47%). Respondents to the survey ranged from 18 to 77 in age. The 2010 Census data for CNMI shows that this survey is fairly representative of the current population of the territory.[10]

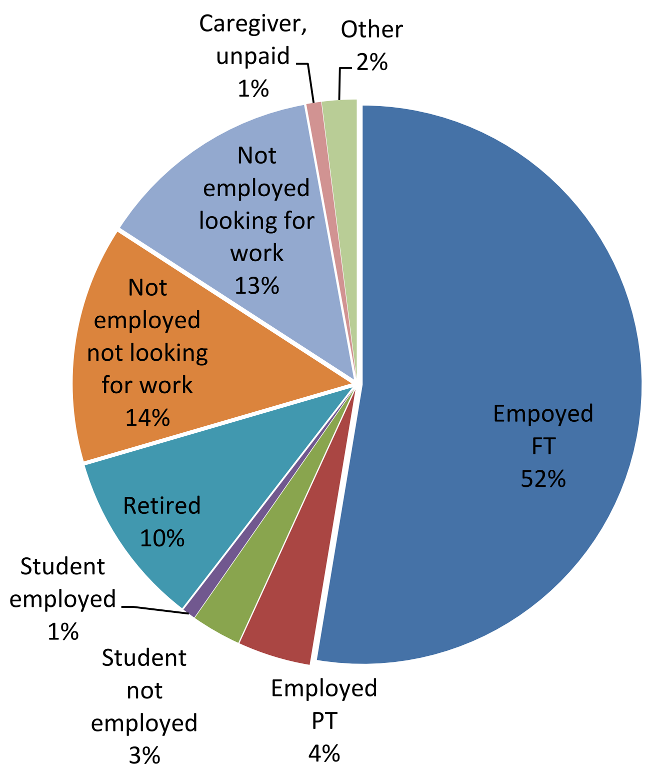
The survey asked respondents for their maximum level of education attained. The options listed were some High School, High School graduate, GED, some college or Associates Degree, Bachelor's degree, some post graduate studies, and post graduate degree. Most respondents had completed High School and nearly a quarter had attended some college or earned an Associate's Degree. The Northern Marianas Islands have public high schools and a community college, but no local Bachelor's Degree programs. Thus, any respondent with a four-year degree earned it outside of CNMI or possibly via distance education programs.

[9] Anatahan, Marianas, Pacific Ocean http://www.vulkaner.no/v/volcan/anatahan_e.html Accessed 10 January 2012.

[10] There were some anomalies in the age data, specifically that more people responded with ages in multiples of 5 than would be expected. For example, 8.6% of respondents stated they were 35, while 1.0 and 1.1 percent of respondents stated they were 34 and 36 respectively. Persons aged 25, 35, 45, 55, and 65 also had significantly higher frequencies than expected. It is possible that respondents were rounding their age or that surveyors rounded ages for the respondents.

Respondents were also asked about their current employment status. Most individuals (52%) were employed full time at the time of the survey. Roughly 69% of respondents could be counted as participating in the labor force (working or looking for work). Those who were unemployed and looking for work accounted for approximately 19% of the labor force. Thus the unemployment rate of the respondents in CNMI was approximately 19%. This differs sharply from the CIA 2005 estimate of 8% unemployment.[11] This shift likely reflects two recent economic developments in CNMI. In 2008, President Bush signed into a law an immigration bill that extended US immigration laws to CNMI.[12] A segment on ABC's *20/20* highlighted "sweatshop" conditions in the factories of CNMI garment manufacturers.[13] The CNMI





[11] CIA World Fact Book, op. cit.
[12] http://abcnews.go.com/blogs/headlines/2008/05/bush-signs-cnmi/
[13] http://abcnews.go.com/Blotter/story?id=4567036&page=1#.Twxx0TVSTSg

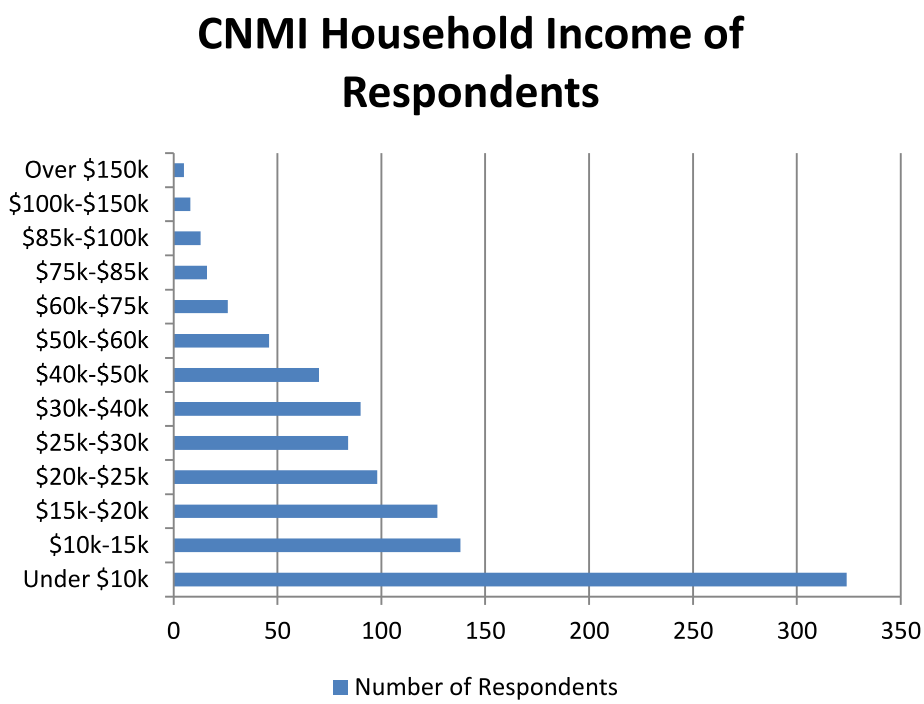
government implemented new minimum wage laws, causing manufacturers to lay off many workers and leading to increasing unemployment. These conditions, coupled with new immigration laws, prompted many residents to leave CNMI, and thus contributed to recent population declines.[14] Even with these population reductions, however, residents remaining in CNMI face significant job shortages, particularly in light of the recent recession.

To measure income, respondents were asked to estimate their total household income from all sources and to select from one of 13 categories. According to One Global Economy survey data, the median household income in CNMI falls between $15,000 and $20,000. The Census 2010 data reported a median income of nearly $20,000[15], which, with a declining population and rising unemployment make it feasible that the current median income would fall below this number. Such a median income, however, is also extremely low by US standards. For comparison, the lowest median household income for a state is Mississippi, which has a median household income of $36,850.[16] With nearly a third of respondents reporting total household income under $10,000, CNMI is quite possibly the poorest state or territory in America.

[14] http://www.pacificnewscenter.com/index.php?option=com_content&view=article&id=19134:first-hawaiian-bank-uncertain-times-for-guam-tourism-a-buildup&catid=45:guam-news&Itemid=156

[15] 2010 Census http://commerce.gov.mp/wp-content/uploads/2012/12/2010-Census-Demographics-Profile-Summary-by-District.pdf

[16] Income of Households by State Ranked from Highest to Lowest Using 3-Year Avearge. http://www.census.gov/hhes/www/income/data/incpovhlth/2010/stateonline_10.xls



The population of CNMI includes residents from a wide variety of different racial and ethnic groups. Through the stakeholder engagement workshops, One Global Economy sought to locate all of the relevant racial/ethnic categories in the area, and included these categories on the survey (only 4 total respondents stated “other”). Most respondents listed Chamorro (40.7%) or Filipino (32.4%) as their ethnicity. A significant minority listed Carolinian (7.1%) as their ethnicity and the remaining population was split over 17 categories including Chinese (3.7%), Caucasian (3.4%), Palauan (2.4%), Korean (2.3%), and Chuukese (1.3%). All other ethnicities had fewer than 10 respondents. When conducting regression analyses, it was necessary to consolidate answers into fewer categories in order to yield significant results. The categories chosen were the largest categories, and included Chamorro, Filipino, Carolinian, Other Pacific Islander, Caucasian, and Other Asian.

Data Analysis

Who Uses the Internet in CNMI?

A primary goal of this report is to understand barriers to Internet access and use. Thus, we begin with an analysis of the characteristics of CNMI residents who do and do not use the Internet at home. In total, approximately 74% of CNMI respondents use the Internet anywhere. This is relatively consistent with Internet use rates in the US as a whole, where 78 percent of residents report using the Internet. A slightly smaller group, 68 percent of all respondents in CNMI, uses the Internet at home. Using the survey data collected, we can begin to develop a profile of these Internet users and non-users.

The following table uses a multivariate, logistic regression to estimate the likelihood that a given respondent uses the Internet at home. The regression includes various demographic factors, including ethnicity, geography, gender, age, education, employment status, household income, and the presence of children in the household. Not surprisingly, respondents who use Internet at home tend to be younger and more educated than non-users are. Respondents with college degrees, for example, are more than three times as likely to use Internet at home than are respondents without college degrees. Internet users also have higher incomes than do non-users.

Interestingly, respondents in households with children under age 18 are more likely than those in households without children to use the Internet at home. A grant by the Department of Education gave laptops to many school-aged children.[17] Thus, it is possible that the computer distribution program has stimulated Internet subscription and led to increased Internet use in the home.

Geography also plays an important part in determining whether residents of CNMI use Internet at home. Home-based Internet use is highest among residents of central Saipan (the area on the west of Middle Road on Saipan, north of Susupe, and South of Tanapag).

[17] http://www.saipantribune.com/newsstory.aspx?cat=1&newsID=102156

Compared to residents in this area, those in South Saipan, East Saipan, North Saipan, Tinian, and Rota are significantly less likely to use the Internet at home, even after controlling for income, education, and age.

Likelihood of Internet Use at Home by Selected Respondent Characteristics (Odds Ratios)

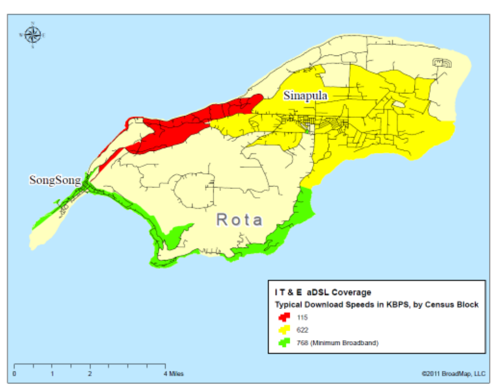
Variable	**Odds Ratio**[a]	**Standard Error**
Age	0.93***	0.01
Income	1.36***	0.05
Education		
Bachelor's Degree	3.72***	0.33
No Bachelor's Degree	--	--
Employment		
Employed	--	--
Not Employed	0.76	0.21
Gender		
Male	0.74	0.18
Female	--	--
Ethnicity		
Caucasian	--	--
Chamorro	0.29	1.16
Carolinian	0.15	2.55
Other Pacific Islander	0.12	1.19
Filipino	0.57	0.38
Other Ethnicity	0.72	1.20
Location		
Central Saipan	--	--

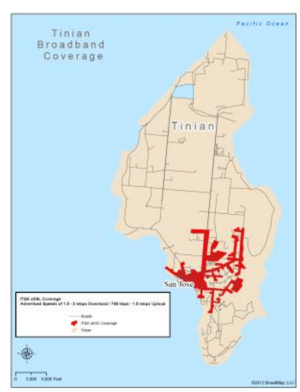
South Saipan	0.19***	0.35
East Saipan	0.21***	0.42
North Saipan	0.25**	0.45
Other Saipan	0.20***	0.36
Tinian	0.21**	0.45
Rota	0.33*	0.45
Any Children in Household	1.36**	0.19

***α<0.001 ** α<0.01 * α<0.05

[a] Odds ratios of greater than 1.00 indicate that a given factor is associated with a higher likelihood of using the Internet at home. For comparative estimates, an odds ratio of greater than 1.00 indicates that a given group has a higher likelihood of using the Internet at home than does the comparison group. Odds ratios of less than 1.00 indicate that a given group has a lower likelihood of Internet use relative to the comparison group. Comparison groups are indicated by a --.

As shown in the maps below, higher Internet download speeds via aDSL seem to be correlated with the areas of central Saipan, where geography proves to be the most significant. Thus, it is possible that the slower speeds available outside of central Saipan may be discouraging residents of those areas from using the Internet or subscribing to broadband.





Interestingly, this analysis also shows that rates of Internet use at home do not vary significantly with respondents' ethnic backgrounds. When controlling for the factors listed above (education, age, income, geography, etc) no ethnic group is significantly different from Caucasians in their likelihood of using the Internet at home. However, if income is not included in the regression, the ethnicities of Carolinian, Filipino, and Other Pacific islander are statistically significant, and indicate that those ethnicities are less likely to use the Internet at home. Thus, the data indicate that the reason why Carolinians, Filipinos, and Other Pacific Islanders may be less likely to have Internet at home is more a matter of income than it is a matter of race.

Other factors that proved to not be significant in determining whether one used the Internet in CNMI included gender and employment status.

Importance of Internet in the Home

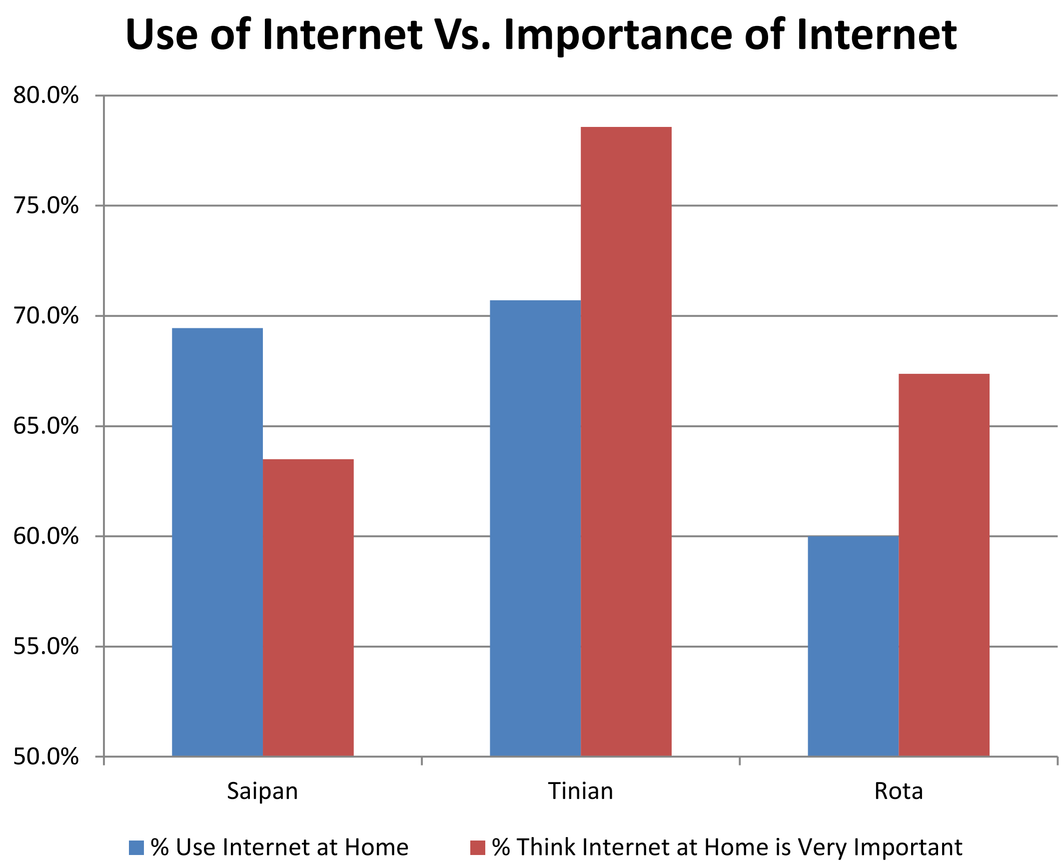
In addition to asking individuals whether they used the Internet at home, One Global Economy also inquired about the importance of having the Internet in the home. Taken together, such questions can help to identify those populations who would like to use the Internet, but cannot because of some real or perceived barrier.

Unsurprisingly, respondents who currently use the Internet at home rank Internet access as more important than do those who do not currently use the Internet at home. Similarly, factors that predict Internet use at home (income, education, age, and the presence of children in the household) are also positively correlated with residents' perceptions of the importance of having Internet at home. That said, there were several findings that ran counter to the usage trends.

For example, Saipan and Tinian have nearly identical rates of Internet use at home (69.5% and 70.7% respectively). However, in Saipan, only 63.5% of residents consider Internet in the home to be very important, while 78.6% of residents of Tinian consider it very important. Furthermore, residents in Rota, who have significantly lower rates of

Internet use in the home (60%) than do residents in Saipan, actually consider it more important to have Internet in the home than do residents of Saipan.

Such evidence points to potential barriers to Internet adoption: When residents consider Internet use in the home very important but are not subscribing at the same rate, there is likely some factor, be it cost, availability, or something else that is preventing them from subscribing to and adopting Internet. We hypothesize that residents of smaller, more remote islands like Tinian and Rota see the utility of home-based Internet access for connecting to online resources in education, entertainment, and commerce. Their desire for these services may also be magnified by their isolation, and by the limited availability of Internet access in public areas (e.g., Internet cafes, gas stations, etc.) on these islands. Some residents of Saipan, in turn, may take for granted the importance of Internet access at home because they can easily go elsewhere to access the Internet (e.g., to an Internet café, a gas station, or their place of business).



Residents' Confusion about Broadband Internet

This report is concerned not only with general rates of Internet access and use, but also, specifically, with residents' access to broadband services. To understand the state of broadband adoption in the Northern Marianas Islands, it is important to first critically examine how broadband is defined. The FCC has officially defined broadband as Internet with maximum advertised download speeds of at least 768kbps. More colloquially, broadband is typically understood as any Internet connection that is faster than dial-up. These distinctions make little difference to most Americans. In the mainland US, Internet service providers (ISPs) rarely offer Internet service with a maximum advertised download speed slower than 768kbps.

In CNMI, however, these distinctions are both blurrier and more important. It is quite common, for example, for ISPs in CNMI to offer Internet service that does not technically qualify as broadband under the FCC's definitions. For example, MCV, the cable provider, offers both high-speed and lower-speed Internet service plans (with the latter plan advertising maximum 128kbps download speed via a cable modem). IT&E, the telephone company based in Saipan, only offers service with advertised maximum download speeds of 768kbps and up. This service would, by the FCC's definition, officially qualify as "broadband." However, residents at town halls frequently reported that their actual speeds did not match the advertised speeds, and were instead much slower. These slower-than-advertised speeds were also confirmed by the online connection speed test.

Given the limited availability of high-speed Internet and the sometimes slower-than-advertised speeds associated with broadband service, many CNMI residents are confused about the definition of broadband and the types of technologies associated with broadband service. For example, 348 residents stated that they used DSL to access the Internet at home; of those 348, 196 stated they did not have broadband at home, even though all DSL plans have advertised downloads speeds of at least 768kbps.[18] Similarly, while 53% of all CNMI respondents stated that they used either DSL, Cable, or mobile broadband to access the Internet at home, (all broadband technologies), only 31% of all CNMI respondents reported having broadband at home.[19]

After the interim survey data report was completed but before the digital inclusion blueprint was finished, IT&E completed its middle mile upgrades of its cable and

[18] IT&E – Internet – ADSL http://www.pticom.com/Internet/ Accessed 12 January 2012.

[19] While some of the 53% may have Cable Internet that does not qualify as "broadband," this does not fully explain the discrepancy in reported rates of broadband access.

microwave link to Guam. This project was funded by the American Recovery and Reinvestment Act and has resulted in faster advertised download speeds for residents.[20] Speed tests conducted by One Global Economy staff on all three islands of the CNMI in September 2012 confirmed that actual download speeds had improved. On prior visits, measured download speeds never surpassed 1mbps. However on the September 2012 visit, One Global Economy staff tested speeds at the same locations and at similar times of day as the previous trip and found speeds nearly always exceeded 2mbps (download).

This confusion regarding the meaning of broadband service was also reflected in the statements that residents made during town hall meetings. The following is an excerpt from an email exchange with a resident who was interested in attending a town hall:

From what I've read, Broadband is on 24/7, for example. I am not at all sure I want that. I'd rather turn it on when I need/want it, and be able to turn it off when I don't. I'm assuming that Broadband is not incompatible with the DSL connection I now have.

The resident thought her DSL connection was *like* broadband, but somehow different. She was also skeptical of this "new" technology, not realizing that her own DSL connection technically qualifies as "broadband" Internet. Like this resident, others also lacked familiarity with the term broadband, and held serious misconceptions about the technology. Many were also unaware that they already had access to broadband at home.

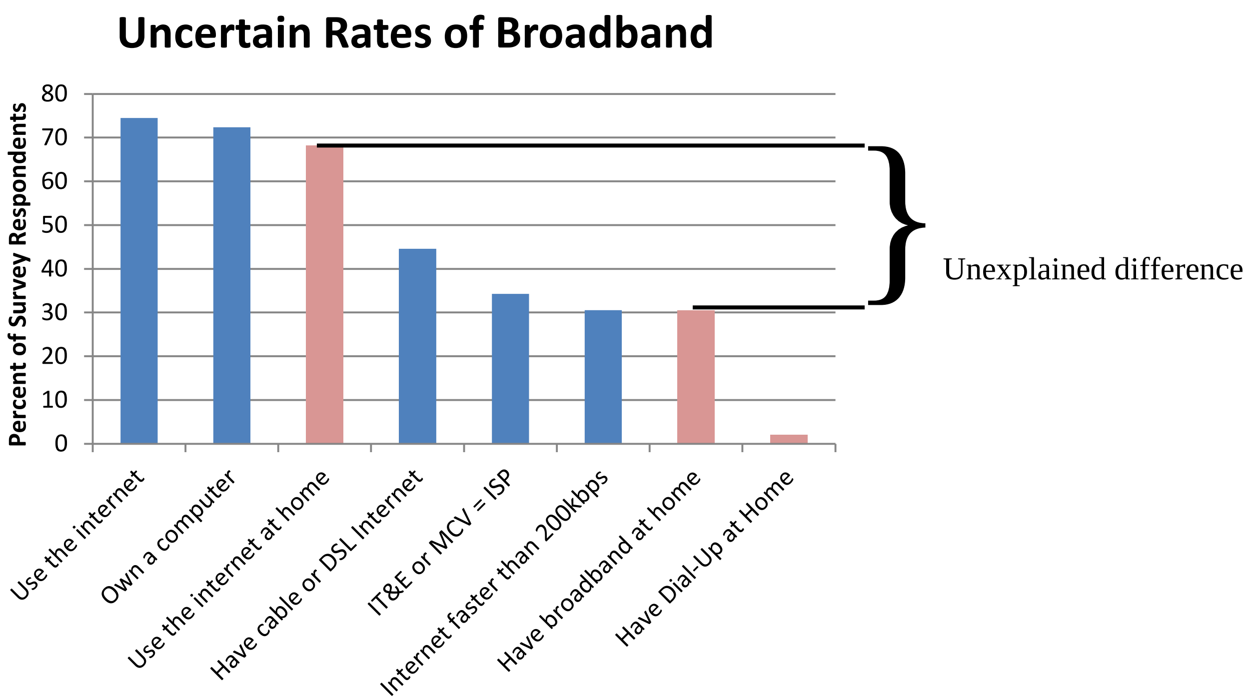
In this analysis, we will consider someone as a broadband subscriber if they stated in the survey that they did indeed have broadband at home; however, we recognize that rates of adoption may be somewhat higher than reported due to misconceptions about the definition of broadband. It is possible that up to 36% of all CNMI residents have broadband at home but do not realize it. It is our opinion that this percentage is lower,

[20] IT&E Doubles and Triples DSL Speeds - http://www.pticom.com/news_and_info.cfm?vzid=40 Accessed 10 October 2012.

likely around 20-25% based on the technologies residents use to connect to the Internet, their stated reasons for not subscribing, and availability maps.

Internet vs. Broadband

As noted above, respondents to the survey and attendees of the town halls had a very difficult time understanding what broadband Internet is. While more than 68% of CNMI residents report using the Internet at home, only 30% report having broadband at home. By comparison, 78% percent of residents in neighboring Guam use the Internet and 72% report having broadband.



One might think that these discrepancies between Internet use and broadband access at home could be accounted for by rates of dial-up use. However, since only 2% of CNMI residents have dial-up Internet service, a sizable gap (35.7% of respondents) remains. It is possible that many of those who do use the Internet at home are unaware of their connection type, their connection speed, or whether or not they have broadband. This seems likely given the extremely high non-response rate for questions regarding service providers (65.7% non-response), speed of connection (60.5% non-response), and type of connection (45.2% non-response).[21] Thus, it is possible that many respondents simply do not know if they have broadband at home. However, nearly every resident responded to questions about Internet use at home (.7% non-response) and about broadband access at home (1.5% non-response). If they were unsure if they had broadband, they certainly tried their best to answer the question, and came down on the side of "no".

Another possibility is that the residents simply do not understand the relationship between ISP, connection type, connection speed, and broadband. Among self-identified IT&E customers, for example, less than 1 percent have dial-up service, yet 16.4% state they do not have broadband. Also, 56.3% of DSL customers state that they do not have broadband (despite the fact that all DSL plans are considered broadband in CNMI). There is also confusion about who provides DSL, as IT&E is the only DSL provider in CNMI, but many respondents stated they had DSL but did not name IT&E as their provider. Overwhelmingly, cable Internet subscribers identified MCV as their ISP, and those that identified MCV as their ISP recognized that they have cable Internet.

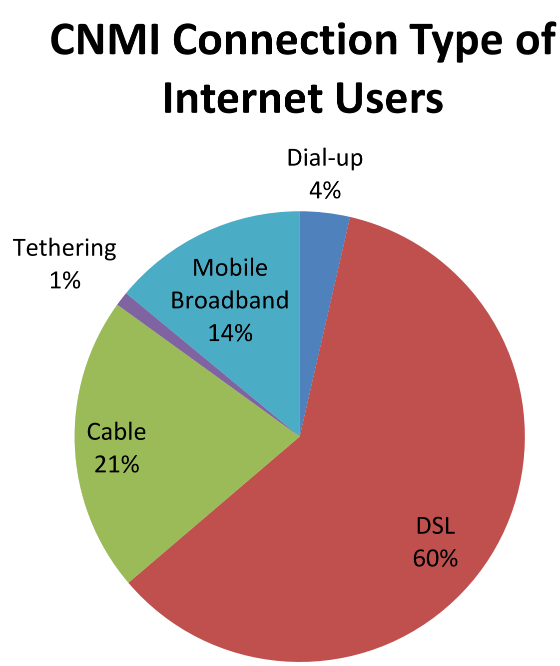
Interviews and town halls also alerted us to a third possible explanation for discrepancies in the reported rates of broadband access at home: the use of neighbors' unsecured wireless Internet networks. The ISPs stated in their discussions with us that they have trouble attracting new subscribers because there are so many venues in CNMI, especially Saipan, that have free un-encrypted Wi-Fi. Most restaurants, cafes, and even some gas stations provide Wi-Fi free of charge and do not encrypt their networks. Thus, it is possible that many CNMI residents who live near these establishments could be using

[21] These high non-response rates may also reflect the fact that a very large number of respondents claimed not to have Internet and/or broadband at home. It is possible that surveyors allowed or encouraged respondents to skip questions about service providers, connection types, and connection speeds once they had answered that they do not have broadband at home. The survey data collected does not distinguish between "not applicable" and non-response.

Internet at home, but not paying for it. Similarly, given the close proximity of dwelling units in neighborhoods throughout CNMI, it is also possible that residents may be using, at home, their neighbors' unsecure wireless networks. At one town hall meeting in Susupe, residents reported seeing kids roaming neighborhoods and going into neighbors' yards with laptops while looking for Wi-Fi signal. If this is in fact true, it would help to explain why so many people who state that they have Internet at home do not know the name of their ISP. It would also explain why there is such a significant gap between those who use the Internet at home and those who have broadband. It is therefore possible that 20 to 30 percent of residents of CNMI are using other subscribers' unsecured Wi-Fi networks at their own homes as their principal means to connect to the Internet.

Technology & Providers

The Northern Marianas Islands' market for consumer broadband services is split by two ISPs- Island Telephone and Engineering (IT&E) and Marianas Cable Vision (MCV). There are additional ISPs such as Pacific Data Systems (PDS); however, they exclusively provide business services. Docomo Pacific, another local provider, does not offer speeds that meet the NTIA or FCC's definition of broadband.[22] Finally Guam Telecommunications Authority (GTA) has begun planning stages to deploy broadband in CNMI but as of January 2012, but is not yet providing service.



Bearing in mind that a high percentage of respondents did not answer the questions on connection type and ISP, there is a higher margin of error in

[22] In September 2012, Docomo Pacific announced
this report, the sale had not been finalized and thu

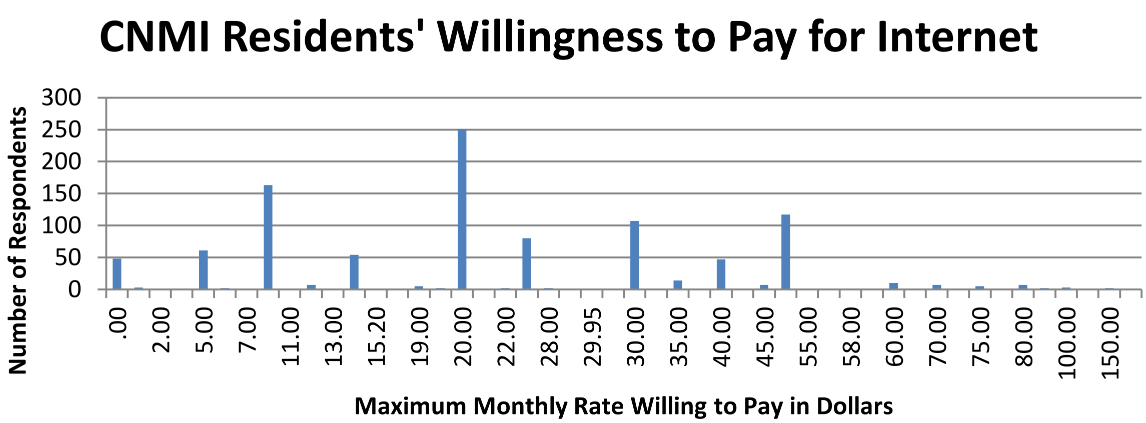
these results. One Global Economy will attempt to better understand the discrepancies through its second round of town hall meetings, but will also try to draw limited conclusions based on the initial data.

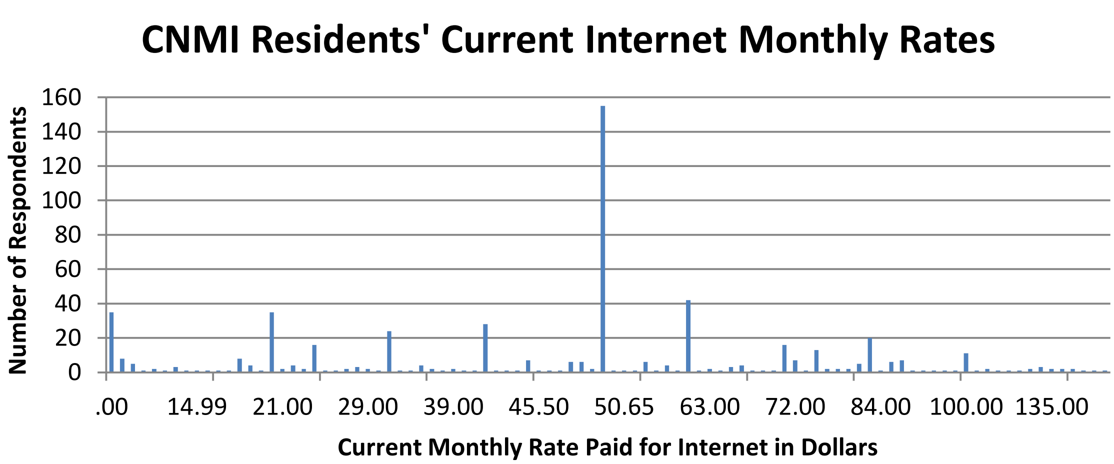
Of those respondents that answered the question about their ISP (366 residents), about two thirds of residents (67.5%) identified IT&E as their ISP and the remaining (32.5%) identified MCV. A larger proportion of residents (585 residents) were able to identify their connection type. Of those, DSL was the predominant mode of reported connection (60%), with Cable (21%) and Mobile Broadband via MiFi or Aircard (14%) constituting a significant minority of the market. IT&E is the sole provider of home DSL service and MiFi/air card services in CNMI. Nearly everyone who has MCV as their ISP is able to correctly identify that they have cable Internet and vice versa. However, those with DSL or mobile broadband have more difficulty identifying IT&E as their ISP.

Willingness to Pay

Residents were asked two open response questions about the cost of their Internet access: they were asked what they currently pay for Internet on a monthly basis (if they have this service), and what is the most they would be willing to pay (regardless of whether they currently have that service). Since the willingness to pay question applied to all residents, almost all residents answered the question. Questions about current Internet costs, however, yielded much lower response rates. While approximately 68% of respondents report having Internet at home, only 54% of respondents reported how much they currently pay. This discrepancy could indicate that respondents did not know how much they pay for Internet or that the question was not applicable to them since they do not pay for Internet at home (i.e., if they are using a neighbor's Internet network).

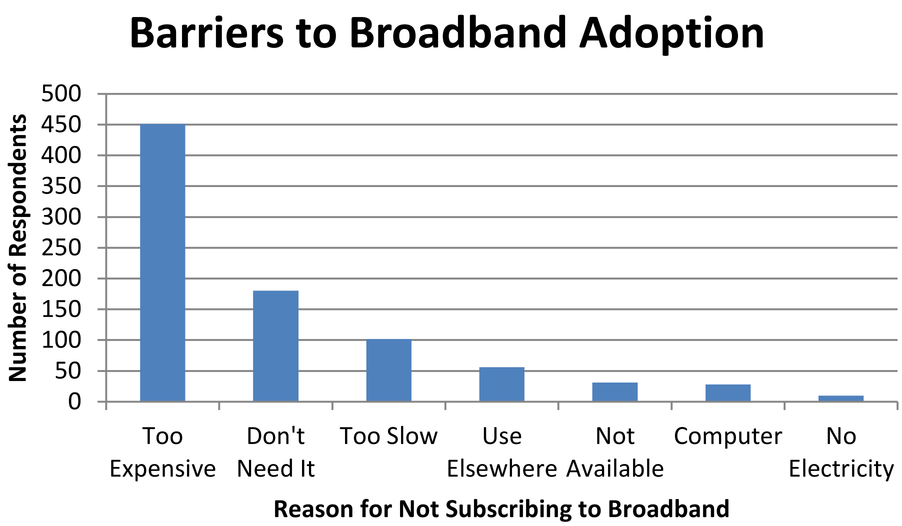
Interestingly, residents generally report paying more than say they are willing to pay. The median rate residents were willing to pay was $20 per month; meanwhile, the median amount paid for Internet was $50 per month. One could argue that because residents who do not pay for Internet at home answered the *willingness to pay* question that they would bring down the average willingness to pay. However, closer examination shows that even those who do subscribe to the Internet are paying more than what they are willing to pay. For example, only 162 residents stated that they were willing to pay $50 or more for Internet each month, while 344 reported actually paying $50 or more per month for Internet.





Barriers to Adoption

Residents who stated in the survey that they did not subscribe to the Internet or broadband were asked to describe their reasons for not subscribing. Given the very low household incomes reported in the demographics section, and the positive correlation between income and Internet access at home, it is unsurprising that the primary barrier to



Internet adoption in CNMI is cost. Of those who state the Internet is too expensive, the majority (73%) live in households with an annual household income under $25,000. However, non-subscribers across the income spectrum (even those earning more than $150,000 a year) reported that cost was an issue. Thus, residents of all income levels view the cost of Internet in CNMI as very expensive (as exhibited in the willingness to pay section) and potentially prohibitive. However, low income residents are more acutely affected than others by these cost barriers.

As exhibited in the coverage maps, almost all areas of Saipan have Internet service available. However, there are significant areas in Tinian and Rota that lack broadband coverage. In Tinian, 5% or respondents, and in Rota, 18% of respondents stated that broadband was not available in their area. For comparison, less than 1% of residents in

Saipan stated that broadband was not available in their area. What this suggests, then, is that barriers to access are particularly high in areas like Rota and Tinian where a substantial minority of residents do not have the option of purchasing Internet service at home, even if they desire to do so.

Survey data can also be used to assess the extent to which the use of a neighbor's Internet connection plays a role in inhibiting broadband adoption. Residents were specifically asked if the reason they do not subscribe to broadband at home is because they can access the Internet elsewhere. That said, very few residents, approximately 12% of those without Internet at home, state that the reason why they do not subscribe to broadband is because they can use it elsewhere. Yet, the primary places that residents use the Internet outside the home are their workplace, their school, or at an Internet cafe. Thus, Internet sharing may not play a significant role in explaining why some residents do not subscribe to Internet at home. Such conclusions are further supported by the fact that respondents who use the Internet outside of their home tend to be wealthier residents who access the Internet at work (white-collar jobs offer greater employer-based Internet access). It is still possible that a significant number of individuals do use a neighbor's Internet network, but did not want to admit to it in the survey. It is also possible that, even if these respondents do opt not to subscribe at home because they can use the Internet elsewhere, they still view cost as the principal reason for non-subscription. If costs were to decrease, it is likely that a greater number of residents would subscribe to broadband at home.

Conclusions

In general, residents of CNMI use the Internet at rates similar to the national average. However, rates of Internet use at home, and in particular, broadband at home, are very low. While part of the gap between Internet use and broadband at home may be attributed to residents' lack of understanding of the various definitions of broadband by the FCC and NTIA, there remain several real and discernible barriers to broadband adoption in place.

It is clear that the cost of a subscription to broadband Internet service is the biggest impediment to universal broadband in the home in the CNMI. The costs are more expensive in CNMI than elsewhere, particularly on the mainland, and the CNMI economy is weak. This is underscored by the nearly complete access to broadband, abundance of hardware due to the program through the schools that gets every student a laptop, and by the stated willingness to pay for broadband.

We know from the survey and from maps from the ISPs that nearly everyone in CNMI has at least some access to broadband if they are willing to pay for it. There are a few small pockets of people that may not have access, but the vast majority of the population does.

The ubiquity of laptops means that it is guaranteed that there is some hardware capable of going online in almost every household. This can be a very expensive hurdle for many families to get over before they can get online and it is not a problem in CNMI.

Respondents to the survey were very willing to pay for broadband, but many could not afford it at its current price. They said that they are willing to pay about $30 - $50 and the majority pay more than that already. Granted, this is less cut and dried because of bundling, but broadband in the home remains financially out of reach for many residents of the CNMI.

Final Internal Short Report

One Global Economy and Governmental Engagement Experience in the United States Commonwealth of the Northern Mariana Island (CNMI)

2012

Prepared by,

Thomas J. Camacho

CNMI Community Liaison

One Global Economy Corp.

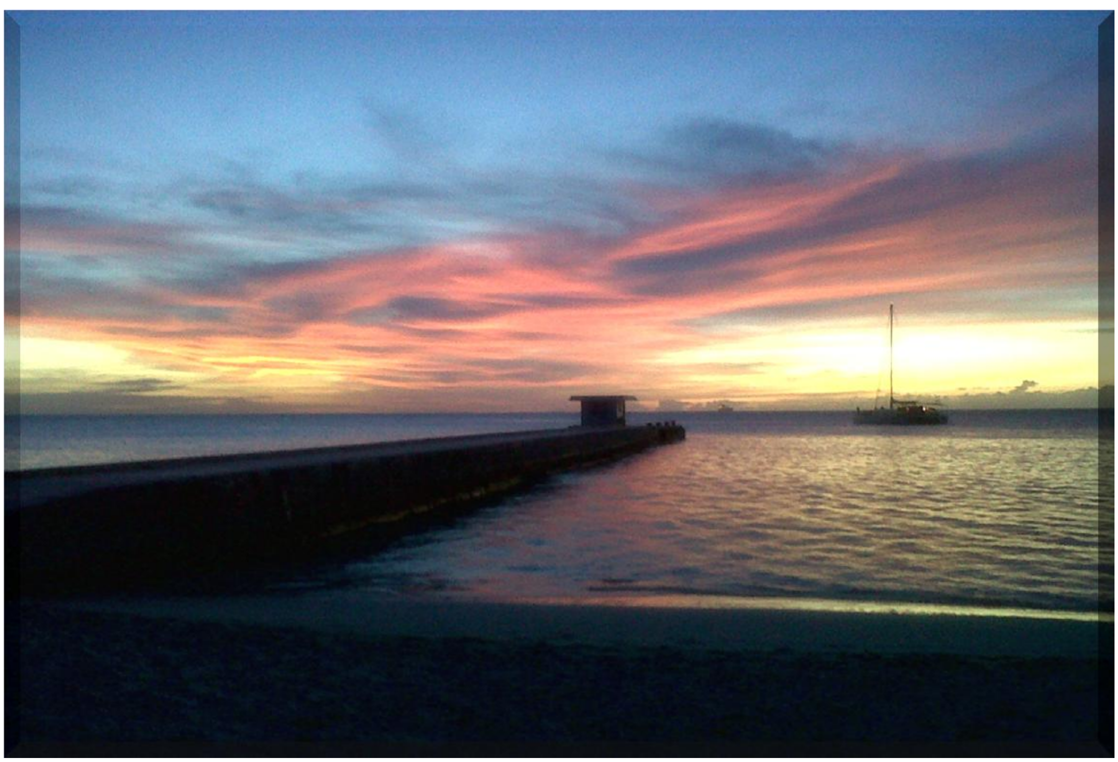
November 6, 2012

Introduction

The following is the CNMI Broadband Mapping Final Internal Short Report of the Findings and Recommendations during One Global Economy's engagement with the CNMI Government. The CNMI Community Liaison organized and facilitated several on-site, community outreach efforts to get more people to take the speed test and facilitated conference calls between non-profit organizations, government agencies and Internet service providers which included visits and meetings on the islands of Saipan, Rota, and Tinian.

This report examines the needs, issues, and ways the CNMI Government can possibly use the report for public policy recommendations and to procure future funding.

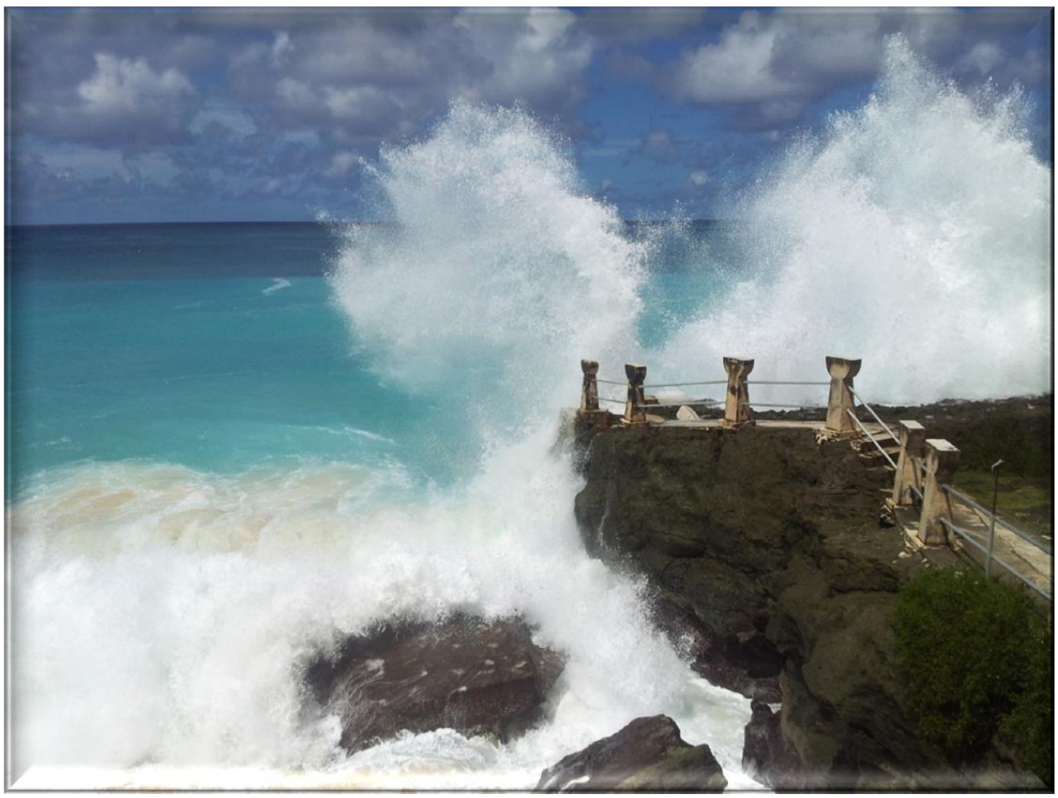
OUTREACH



Comments and suggestions from each island meetings

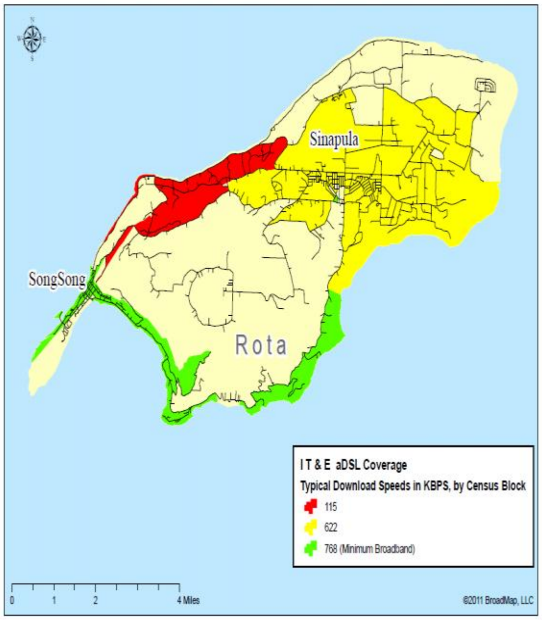
Island of Tinian

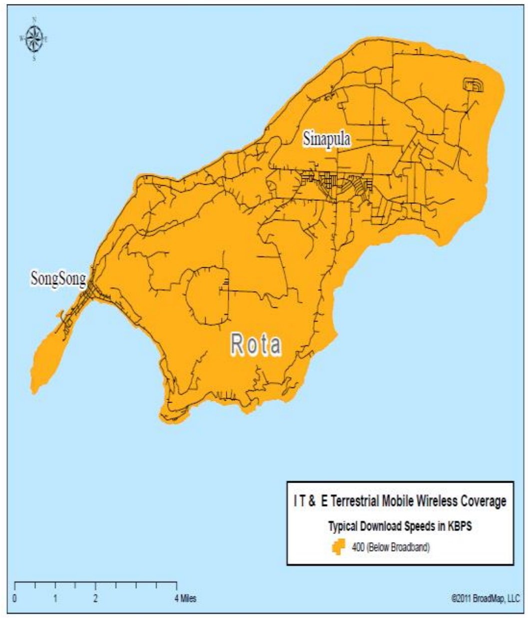
We met with representatives of various Tinian government agencies and offices at the Tinian Public Library. There we learned that as of the beginning of the 2012 school year, students are now being required to take classes online, so, according to one government employee, “we need the best—and most affordable—Internet access possible.”



We also met with the principal of Tinian High School to get his view on Tinian’s broadband Internet services and feedback about the newly activated online courses. While the program is in operation as planned, there are still issues that need to be addressed. For example, traffic and overloaded T-1 lines cause slower Internet speeds, which, in turn, hamper students’ abilities to complete the online courses. The principal welcomes the final broadband report, a tool he intends to use as a reference when preparing the school's grant applications.

Island of Rota





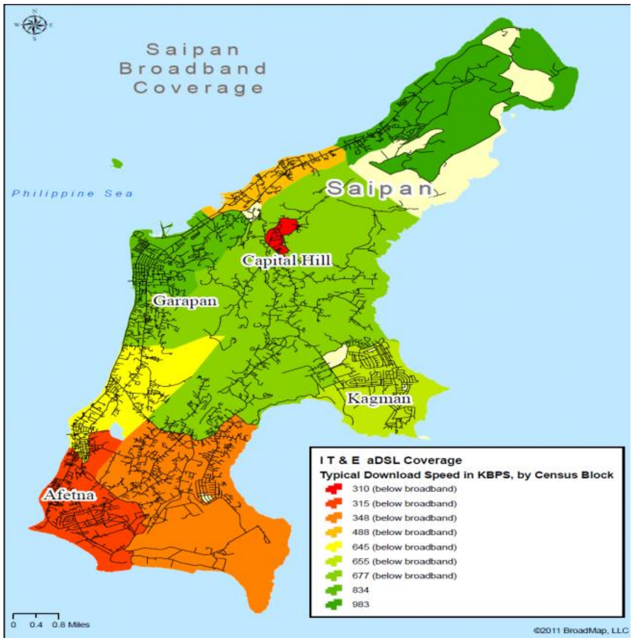
While in Rota, representatives from One Global Economy met with several government employees and officials representing different branches of government. According to one government official via email, "The meeting conducted by One Global Economy was very informative."

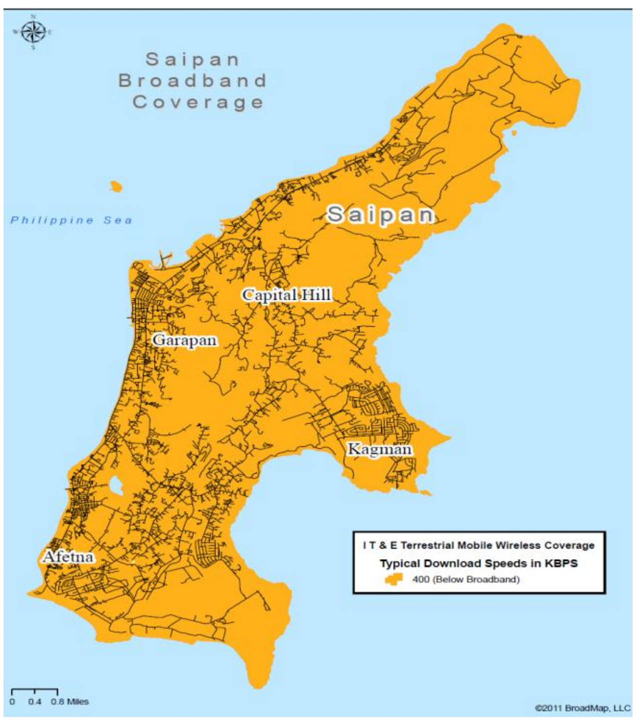
What came about during that meeting was that many of the residents of Rota are unaware of the upgrades that IT&E has made. They think that the FCC should be made aware of Rota’s situation so that ARRA funding provided to IT&E to upgrade its middle-mile capacity is achieved. People still believe that current services provided are too expensive and the quality is poor, but it is undeniably improved. Residents of Rota also feel the lack of competition. IT&E has a complete monopoly on Internet service on the island and that severely limits residents’ choices and inflates broadband’s cost on Rota.

Moreover, the government representative said, “It is very good that One Global Economy was in Rota to witness first-hand the very poor and inadequate service being provided at a very unreasonably high price.”

The intention of the ARRA funding is to improve broadband service to the community. There is much work to be done, even though IT&E now provides better service.

Island of Saipan





At the meeting with government agencies held at the Multi-Purpose Community Center, one of the representative from the public school system echoed this same sentiment during the meeting and via email, “We at the Public School System depend heavily on affordable, reliable, and accessible Internet services as we have been providing our secondary schools with netbooks, technology based curriculum, and resources that require Internet connections.

“Demand for Internet access is skyrocketing and it seems that there will never really be enough as the schools and students are constantly demanding more every year. Although speeds have been upgraded, we are still very far from getting speeds that subscribers are actually paying for. Lastly, I also echo comments stated below that COST is one of the biggest road blocks preventing people from obtaining broadband services. As for the data collected, the PSS can use this to show how the netbooks distributed to our students are allowing them to access online resources which otherwise would not have been available. Kudos to IT&E for making Internet access available to the community through DSL connections being provided at various centers!”

Moreover, “My only recommendation that I think will make a huge impact to the end user is to remove the requirement to have a home or business telephone number in order to have Internet access or an ADSL account. If a telephone number is not required anymore for any ADSL account then ADSL will be cheaper. Besides, there are so many stand-alone VoIP appliances you can buy on the market if the end user still needs a telephone at his or her home. Almost all the villages have dry copper anyway.” The CNMI government and the community, after learning of Guam’s GTA Telephone company plans to bring cable, telephone, and broadband Internet to the CNMI, are somewhat relieved and hopeful that broadband Internet rates will be more competitive and affordable.

Conclusion:

The task of transforming CNMI's economy and society into a successful digital economy is a significant one that requires a long-term focus. It is essential for the CNMI Government, broadband Internet providers, and the community to work together to ensure that CNMI is well on the path to a successful digital economy.

These must approach the task recognizing that this is a process which touches all aspects of our economy and society. CNMI is not alone in realizing the magnitude of this challenge. A good example is our Pacific Island neighbor of American Samoa, a place that is encountering similar challenges such as the high cost of delivering broadband

Internet services to businesses, government, and homes. The CNMI should look into policies that are less sector-specific and more a part of the mainstream economic policies that concern the economy and society as a whole.

Stakeholders should align with other important CNMI government initiatives, policies, and regulations to enable CNMI to become a more innovative Pacific region with world-class infrastructure that supports smart, effective, and rewarding use of technology throughout all aspects of our economy and society. With the help of One Global Economy's nearly two years of research and efforts in developing the CNMI's broadband mapping and the digital blueprint, the CNMI government should provide the vision underlying the government's existing commitments to establish or support the FCC National Broadband Plan and must ensure existing broadband Internet providers provide the most reliable and affordable Internet with speeds that, at the very minimum, qualify as broadband.

The FCC National Broadband Plan through recommendations to be presented by One Global Economy on behalf of the CNMI Government, in particular, will hopefully lead to or allow the CNMI to become a Pacific Island leader in terms of capacity and enjoy truly high speed carrier grade video, data, and voice services.

A Comparative Analysis of Reported and Measured Broadband Service in the Commonwealth of the Northern Mariana Islands

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Director, Wireless Future Project

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Econometric Research and Analysis

Prepared for

The Commonwealth of the Northern Mariana Islands and One Global Economy

October, 2012

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I. Introduction

This study analyzes broadband access, service and measured performance data (e.g., actual user download and upload speeds and latency) in the Commonwealth of the Northern Mariana Islands (CNMI) and compares CNMI's situation to Hawaii and four other U.S. island territories. It is based, in part, on broadband serviceability data and maximum and minimum advertised download/upload speeds reported by incumbent Internet service providers (ISPs) to BroadMap, as of May 2012, and made public as part of National Telecommunications and Information Administration's (NTIA) National Broadband Map. BroadMap is a contractor that aggregates regional ISP data for CNMI's reporting of data for the National Broadband Map.

The study augments this ISP-reported data with detailed demographic data from the U.S. Census Bureau and with independent real-time broadband performance measured as download/upload speeds and several measures of latency (delay), collected from voluntary consumer tests run on the independent Measurement Lab (M-Lab) global server platform co-sponsored by Google Inc. and the New America Foundation's Open Technology Institute. These data for CNMI are compared to data collected by M-Lab for the other U.S. Pacific Territories – Guam and American Samoa – as well as to data reported to the NTIA's National Broadband Map for Hawaii, Puerto Rico, and the U.S. Virgin Islands.[23] M-Lab performance measurements of actual broadband download and upload speeds and latency for CNMI are compared to M-Lab metrics for Hawaii, Puerto Rico, and the U.S. Virgin Islands, as well as to the state of Mississippi and a number of advanced and less developed nations in

[23] The broadband mapping data for the U.S. Pacific Territories were provided by BroadMap; the broadband mapping data for Hawaii, Puerto Rico, and the U.S. Virgin Islands were collected from the National Broadband Map operated by NTIA (http://www.broadbandmap.gov/). Both datasets were funded by the U.S. Department of Commerce under the American Recovery and Reinvestment Act. These data will be normalized for statistical analysis by a logarithmic transformation; see Appendix 1 for a more detailed discussion of this technique.

Europe.[24] The M-Lab data, as well as limited speed-testing data collected by BroadMap, are used to evaluate whether advertised speeds are reflected in real-time performance. Broadband speeds, whether advertised or measured, are listed in megabits per second (Mbps).

Regressions on the M-Lab performance variables substantially confirm that urbanization, higher economic status, and Caucasian ethnicity are strongly associated with better broadband speeds and quality of service; and that rurality, lower economic status, and non-white ethnicity are associated with lower actual levels of broadband quality. **The results are particularly troubling since they indicate that absent public policy interventions aimed at offsetting demographic disadvantages – particularly low household income, rurality, education and ethnic minority status – most of the population of CNMI and the other U.S. Pacific Territories, as well as Puerto Rico and the U.S. Virgin Islands, may be permanently condemned to inferior broadband service for intractable economic and sociological reasons.**

U.S. Census Bureau demographic, social, economic and housing data are also assessed in order to investigate the relationship between ISP-reported broadband provision and quality, on the one hand, and socioeconomic differences between CNMI and the other U.S. Pacific Territories, Hawaii, Puerto Rico, and the U.S. Virgin Islands, on the other hand.[25] A detailed discussion of methodology can be found in Appendix 1. Hawaii, Puerto Rico, and the U.S. Virgin Islands were chosen as additional comparison cases for a number of reasons. While Hawaii has demographic and geographic similarities to the U.S. Pacific Territories, it is substantially more economically developed, has a larger population, and enjoys the benefits of statehood. Puerto Rico is also a U.S. territory with similar economic problems, although it has a larger population and a large minority population (Hispanic and

[24] Because the M-Lab data includes natural zeros a logarithmic transform was not performed on the data; see Appendix 1 for a discussion of the issue.
[25] U.S. census data for 2000 is used rather than 2010 data because the full report of census data from 2010 has not yet been released for the U.S. Pacific Territories.

Afro-Hispanic, rather than ethnic Hawaiian as is the case of the U.S. Pacific Territories). Puerto Rico seems an excellent comparison case for estimating the role of poverty, rurality and ethnicity in affecting broadband deployment and performance. The U.S. Virgin Islands were chosen because of their similar population size, the presence of ethnic minorities, the relative impoverishment of the islands, and the high degree of rurality.

II. ISP-Reported Data: CNMI Compared to Hawaii and Other Territories

At the outset of our investigation, we expected to be able to identify differences in demographic and economic variables (including income, employment levels, rural vs. urban, etc.) that would correlate well with the ISP-advertised speed data and the number of competing wireline ISP variables across particular census tracts in CNMI. For example, within most mainland states, we would expect to find and explain significant differences in broadband access (e.g., number and types of competing ISPs) and quality (e.g., download/upload speeds) among quite a few census tracts. In CNMI, by contrast, it quickly became apparent that such intra-island comparisons within CNMI are not statistically significant. Demographic, economic, and social characteristics have relatively low standard deviations that suggest they do not vary very much by Census tract across CNMI (or any of the U.S. Pacific Territories) because each territory has a relatively homogenous population, at the census tract level, and are small enough that ISPs appear generally to deploy and advertise island-wide.[26]

[26] While there is ethnic clustering geographically in CNMI, this is a case where an empirical distribution does not add up to statistical significance. The standard deviations of the census variables across census tracts in CNMI tend to be quite small. But an even more intractable problem is that we have only a limited set of ISP-reported variables against which to regress the census variables. The number of wireline ISPs does not vary much across the islands, which should be expected since CNMI's populated areas are small enough that it makes economic sense to deploy everywhere if you are going to deploy anywhere). There is not enough variance in the outcome variables on an intra-island basis to produce reasonable regression results. When you regress the census variables on the ISP advertised speed variables, a similar problem arises and you get R^2s in

The exception to this relative homogeneity is ethnic composition. However, even pockets of ethnic concentrations by geography do not appear to correlate with significant differences in the number of wireline ISPs or advertised broadband speeds across the census tracts.[27]

There are several reasons why the availability of broadband and its advertised quality does not vary significantly across CNMI. First, CNMI has a small population that is more uniformly low-income, at least relative to the 50 U.S. states. CNMI's per capita income is just $9,151, a full $10,826 lower than Mississippi, the poorest state. Similarly, CNMI has nearly twice the share of its families at or below the poverty level than Mississippi (30.6 percent to 16.7 percent) and nearly five times as many households without telephone service (29.9 percent to 5.9 percent), which are proxies for both rurality and poverty, based on the most recent available Census data.[28] CNMI's percent of workforce employed is, however, higher to Mississippi (61.8 percent to 53.5 percent).

CNMI is also a very small place: its 463.3 square kms in land area is less than twice that of than Staten Island (265.5 square kms), one of the five boroughs of New York City. CNMI's total population is less than 54,000,[29] with nearly ninety percent of the population living on Saipan, the largest island in the Marianas chain. If CNMI's residents were transported to Mississippi, they would be the tenth largest county and comprise less than 2 percent of the state's population. CNMI's

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the 0.0211-0.0279 range. This is an artifact that the ISPs tend to offer pretty much the same speed packages. When you try probit regression on technology-type dummy variables with the census variables, the equations fail to converge, again because of lack of variation.

[27] As explained in note 4, just above, while there is ethnic clustering geographically in CNMI, this is a case where an empirical distribution does not add up to statistical significance.

[28] As noted above, because the Census Bureau has not released its report on the 2010 census survey data for the U.S. Pacific Territories, and reportedly will not until 2013, U.S. census data for 2000 is used rather than 2010 data throughout the report, except where noted to the contrary.

[29] According to a U.S. Census Bureau, the 2010 census count for the CNMI was 53,583 as of April 1, 2010. This represented a decrease of 22.2 percent from the 2000 Census population of 69,221. "U.S. Census Bureau Releases 2010 Census Population Counts for the Commonwealth of the Northern Mariana Islands," U.S. Census Bureau News Release, August 24, 2011, available at http://2010.census.gov/news/releases/operations/cb11-cn178.html.

relatively high population density also tends to reduce demographic and economic variability. The inability to isolate differences in broadband access and quality based on location or demographic characteristics within the territory is at least as acute for Guam and American Samoa. These are small and relatively crowded islands. Guam has a population of 159,400 and American Samoa a population of 55,500 (based on the 2010 Census Bureau counts). Guam has a land area (540 square kms) that is roughly twice the size of Staten Island, while American Samoa is even smaller (200 square kms).

All of this is complicated by the fact that both the wireline incumbent ISPs tend to advertise the same services at the same speeds across CNMI.[30] The ISPs operate island-wide and the reported data suggest they did not engage in significant speed or price differentiation, at least not until very recently (and after the period covered by the data in this study).[31] As a result, the census variables have very little to vary against on availability, speed or price. The same problem exists also for Guam and the American Samoa. Since we found no empirically significant differences in ISP-reported access and advertised speeds within CNMI itself, this section concentrates instead on demonstrating the more empirically and statistically significant differences between CNMI and the other U.S. Pacific Territories, as well as between CNMI and Hawaii and other U.S. territories in the Atlantic (Puerto Rico and U.S. Virgin Islands). For example, the differences between CNMI and Hawaii over most of the ISP-reported variable values are striking.[32] The mean number of wireline ISPs for Hawaii is significantly higher than that for CNMI (the mean difference is 3.29 ISPs), as are the Hawaiian means

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[30] All references to advertised download/upload speeds in this report are to data provided to BroadMap by local ISPs or to other National Broadband Map project contractors.

[31] On September 11, 2012, the provider IT&E in CNMI substantially upgraded the advertised speeds for their DSL plans, while keeping prices roughly the same. This change is not reflected in the data analyzed here, which is all prior to September 2012. According to IT&E's news release, "Customers who currently enjoy download speeds of up to 768kbps on DSL Nitro will have twice the bandwidth with speeds up to 1.5Mbps on DSL Basic. Customers who currently enjoy download speeds of up to 1.0Mbps on DSL Supercharge will receive speeds up to 2.5Mbps on DSL Advantage. Customers who currently enjoy download speeds of up to 1.5Mbps on DSL Turbocharge will receive speeds up to 4.0 Mbps on DSL Extreme." IT&E, "IT&E Doubles and Triples Speeds," News Release, Sept. 11, 2012, available at *http://www.pticom.com/news_and_info.cfm?vzid=40* (viewed Oct. 22, 2012).

[32] See Appendix 3, Table 8.

for the low and high end of the maximum advertised *download* speeds range (the mean differences are 1.09 Mbps and 3.86 Mbps, respectively) and the low and high end of the maximum advertised *upload* speed range (the mean differences are 1.44 Mbps and 3.58 Mbps).[33] This indicates that **residents of Hawaii benefit from substantially more broadband providers, competition and quality than the residents of CNMI.** Although this may not be surprising given disparities in economic development, infrastructure investment and relative affluence between Hawaii and any of the U.S. Pacific Territories, **since broadband is increasingly an input into the production of most other knowledge, goods and services, it is also a critical indicator that this gap in growth and prosperity will persist in the absence of a concerted policy intervention.**

A. Number of Wireline ISPs

The number of ISPs in each of the U.S. Pacific Territories is not large. CNMI has a median of two wireline ISPs operating in each district, the same as American Samoa, while Guam has a median of three wireline ISPs. Guam has a significantly higher mean number of ISPs than either American Samoa or CNMI.[34] CMNI has the lowest mean and median numbers of wireline ISPs among the three U.S. Pacific Territories, as Table 1 shows:

Table 1

[33] Note that these mean differences are exponentiations of the logarithms in Table 8. Column 2 of Table 8 is showing the logarithmic difference, since the datasets were logarithmically transformed. Then they were converted (exponentiated) in order to derive the numbers in the text that can be interpreted empirically.
[34] See Appendix 3, Tables 4-5.

Mean and Median Values of Number of Wireline Internet Service Providers, U.S. Pacific Territories

	Number of Internet Service Providers per District/Village	
	Mean	Median
American Samoa	1.9429	2.0000
Commonwealth of the Northern Marianas Islands	1.8313	2.0000
Guam	3.0000	3.0000

Source: BroadMap

These differences are probably due to the larger population of Guam, the presence of several U.S. government installations there, and the fact that it is the junction point for several undersea telecommunications cables.

As noted above, differences in mean number of wireline and wireless Internet service providers[35] within territories and between districts/villages were tested by t-test and not found to be statistically significant;[36] nor were differences in maximum advertised download/upload speeds within territories

[35] See Appendix 3, Table 3.

[36] Sample distributions with unequal variances precluded use of ANOVA techniques and Student's t-tests of differences between sample means. Welch's t-test is a test of the null hypothesis that there is no difference between the means of two samples and is used where the variances of the two samples are unequal. It was used in all case in this study. See Appendix 1 for a more detailed explanation of Welch's t-tests.

and between districts/villages in those territories found to be statistically significant. However, differences between CNMI, Hawaii and the other island territories were statistically significant.[37]

To explain these differences, t-tests were run, comparing the means of number of ISPs for CNMI, Hawaii and the other territories in terms of the U.S. Census demographic, social, economic and housing variables (see Appendix 2 for the census variables). Those variables with statistically significant differences between CNMI and the other U.S. Pacific Territories were then selected for testing in regressions on the number of ISPs, and the minimum and maximum advertised download/upload speed variables.[38] The expectation was that several explanatory variables would be revealed that would account for a significant amount of the variation in the dependent variables. The results comparing CNMI with each of the other five island jurisdictions follows.

1. Comparing CNMI and Hawaii: Number of ISPs and Demographics

The differences between CNMI and Hawaii over most of the ISP-reported variable values are striking.[39] The mean number of wireline ISPs for Hawaii is significantly higher than that for CNMI (the mean difference is 3.29 ISPs).[40] Regressions of relevant census variables were run on the number of wireline ISPs in CNMI and Hawaii.[41] The expectation was that several explanatory variables would be revealed which would account for a significant amount of the variation in the dependent variables.

[37] The t-test is a statistical technique that assesses whether the means of two groups are *statistically* different from each other. The t-tests used in this study are Welch's t-tests. All t-tests test whether the differences between means of two or more groups are statistically significant. Welch's t-test is used when the variances of the groups are not equal, as is the case with the data here.
[38] For an explanation of ordinary least squares regression techniques see Appendix 1.
[39] See Appendix 3, Table 8.
[40] For Hawaii, these include three small, primarily outer-island companies.
[41] See Appendix 3, Table 9. Initially, t-tests were run, comparing the means of CNMI and Hawaii in terms of the U.S. census demographic, social, economic and housing. Those variables with statistically significant differences between CNMI and Hawaii were then selected for testing in regressions on the number of ISPs. In the regression the coefficient for the dummy variable for Hawaii was dropped for insignificant t-values.

Appendix 3, Table 9 shows the results of a regression analysis based on demographic differences between CNMI and Hawaii. As one would expect, the coefficients for variables associated with prosperity – per capita income and higher total population – are all positively signed, indicating their association with higher values for the number of ISPs. The coefficient for a variable associated with poverty and rurality – percent of families at or below the poverty level and percent of homes without telephone service – are negatively signed, indicating their association with lower values for the number of ISPs.

These results indicate that higher levels of population, higher levels of affluence are associated with the presence of a larger number of wireline ISPS. The percent of homes without telephone service, a proxy for both rurality and poverty, is associated with the presence of a smaller number of wireline ISPs, as is the explicit measure of percent of families at or below the poverty level. Dummy variables for ADSL, cable, fiber service were dropped for insignificant t-values. The regression variables account for 99.39 percent of the overall variation in the number of wireline ISPs. These results are consistent both with the t-tests of differences between Hawaii and CNMI as well as the comparisons among the U.S. Pacific Territories.

2. Comparing CNMI and Guam: Number of ISPs and Demographics

Appendix 3, Table 7 shows the results of a regression analysis based on demographic differences between Guam and CNMI. Guam's residents generally have access to a choice among more ISPs and faster broadband speeds than do the residents of CNMI. This result that can be explained almost entirely by higher levels of poverty and rurality in CNMI (e.g., homes without telephone service) than in Guam.

In the regression, the dummy variable for CNMI is appropriately signed, since the average number of wireline ISPs is less for CNMI than for Guam. Also very important are the variables with negatively-signed coefficients: percent of workforce engaged in agricultural industry, percent of families at or below the poverty level, and percent of houses without telephone service. These are indices of both poverty and rurality and are inverse to the number of wireline ISPs. In other words, **the higher the percent of workforce engaged in agricultural industries, the higher the percent of families at or below the poverty level, and the higher the percent of houses without telephone service – all indices of rurality and poverty -- the lower the number of wireline ISPs will be.**

Conversely, higher total population, higher percentage of the population employed and higher per capita income all militate for a larger number of wireline ISPs. **The model accounts for 92.99 percent of the variation in number of wireline ISPs.**

3. Comparing CNMI and American Samoa: Number of ISPs and Demographics

Appendix 3, Table 6 shows the results of a regression analysis based on demographic differences between CNMI and American Samoa. American Samoa has a wider distribution of ISPs than CNMI, i.e., both wireline ISPs deploy in a larger number of census tracts in American Samoa. Higher relative population density and a higher median household income in Samoa are associated with larger numbers of ISPs. Conversely, percent of workforce engaged in agricultural industry and percent of homes without telephone service militate for lower numbers of ISP per census tract. **The model accounts for 99.99 percent of the variation in number of ISPs between the two territories.**

4. Comparing CNMI and Puerto Rico: Number of ISPs and Demographics

The differences between CNMI and Puerto Rico over most of the ISP-reported variables favor Puerto Rico, but are far less striking than the differences between CNMI and Hawaii. The mean number of ISPs for Puerto Rico is significantly higher than that for CNMI (the mean difference is 0.479 ISPs), as is the mean for the low and high ends of the maximum advertised download speed range (mean differences are 1.36 and 0.449 Mbps), as well as maximum advertised upload speeds (the mean differences are 1.70 Mbps and 0.726 Mbps). The ISP data suggest that households in Puerto Rico benefit from more choice and competition.

Appendix 3, Table 11 shows the results of a regression analysis based on demographic differences between CNMI and Puerto Rico. T-tests were run, comparing the means of CNMI and Puerto Rico in terms of the U.S. Census demographic, social, economic and housing variables.[42] Those variables with statistically significant differences between CNMI and Puerto Rico were then selected for testing in regressions on the number of ISPs, and the minimum and maximum advertised download/upload speed variables. The expectation was that several explanatory variables would be revealed which would account for a significant amount of the variation in the dependent variables.

In the regression the coefficient for the dummy variable for CNMI was negatively signed and with the second highest absolute value, reflecting the fact CNMI has significantly fewer wireline ISPs than Puerto Rico.[43] Percent of workforce employed and per capita income were signed positively and reflect the fact that greater urbanization and higher income favor more ISPs, while rurality, as reflected in the negatively-signed percent in agricultural industry and percent of homes without telephone service, is strongly associated with lower numbers of ISPs. **As we saw with respect to Hawaii, a relatively greater degree of poverty and rurality in CNMI is associated with**

[42] As noted above, a t-test is a statistical technique that assesses whether the means of two groups are *statistically* different from each other. The t-tests used in this study are Welch's t-tests. All t-tests test whether the differences between means of two or more groups are statistically significant. Welch's t-test is used when the variances of the groups are not equal, as is the case with the data here.
[43] See Appendix 3, Table 10.

significantly fewer wireline ISPs than Puerto Rico, while wealth and higher population is associated with more.[44] The regression accounted for 92.07 percent of variation in number of wireline ISPs.

5. Comparing CNMI and U.S. Virgin Islands: Number of ISPs and Demographics

The U.S. Virgin Islands (USVI) does better that the CNMI on most of the ISP-reported variables in the study.[45]

Appendix 3, Table 13 shows the results of a regression analysis based on demographic differences between CNMI and the U.S. Virgin Islands (USVI). To explain why USVI has on average more wireline providers than the CNMI, as well as faster advertised speeds offered, t-tests were run comparing CNMI and the USVI in terms of the U.S. census demographic, social, economic and housing variables. Those variables with statistically significant differences between CNMI and the USVI were then selected for testing in regressions on the number of ISPs, and the minimum and maximum advertised upload and download variables.

Income and total population, a measure of urbanization, were predictors of higher numbers of wireline ISPs, while percent of workforce engaged in agricultural industries of poverty and rurality was a predictor of lower numbers of wireline ISPs. **The regression variables overall account for 88.80 percent of the variation in the outcome variable**.

B. Maximum Advertised Download/Upload Speeds

Households in Guam are offered a higher range of maximum advertised download speeds than either American Samoa or CNMI, as well as a higher maximum advertised upload speed (at the

[44] Dummy variables for ADS and cable service were dropped for insignificant t-values.
[45] See Appendix 3, Table 12.

top end of the range). The wireline broadband offerings in CNMI were also markedly inferior to the average download and upload speeds offered in Hawaii, at least during the period of this study (through August 2012).[46] The difference with offerings in Hawaii and the other four island territories (Guam, American Samoa, Puerto Rico and U.S. Virgin Islands) are presented below.

With respect to the factors explaining these differences in the speed of ISP offerings, while we found clear associations between demographic differences and the average number of wireline broadband providers (see section A), the correlation analysis between ISP-reported broadband speeds and demographic differences between CNMI and the other island jurisdictions was mostly inconclusive, with one exception: **higher advertised speeds are offered in the markets with higher average household income (that is, higher in Guam than American Samoa and CNMI, but higher in Hawaii than in Guam).**

In running the regression analyses, correlation coefficients were calculated for the census variables and the maximum advertised upload and download speed variable. One of the few correlations with a relatively high coefficient and statistical significance – the correlation between per capita incomes with the high end of the maximum advertised *download* speed range (0.5683) – suggests **one possible explanation of advertised speed variation: higher speeds are marketed in areas with higher per capita income.**

There seems to be little reason to regress the census variables on the maximum advertised download and upload speeds for CNMI and the other U.S. Pacific Territories, since their correlation coefficients tend to be so small. This is evidence for those who advocate requiring the National Broadband Map to collect actual, measured speeds: advertised speeds correlate poorly to empirical

[46] All referenced advertised upload and download speeds are either provided by local ISPs to BroadMap or by local ISPs to another National Broadband Map contractor. As noted above, in note 9, in September 2012 the provider IT&E in CNMI substantially upgraded the speeds for their DSL plans, while keeping prices roughly the same. This change is not reflected in the data analyzed here, which is all prior to September 2012. *See* http://www.pticom.com/news_and_info.cfm?vzid=40.

data about performance because (1) they represent idealized maxima of a given technology which are seldom regularly realized by actual users and (2) they are arbitrary artifacts of ISP advertising packages offered over the entire territory, which yields data that associates particular speed/price packages with widely varying values for demographic, social, and economic variables. There may be some evidence for higher speeds being associated with higher per capita income, but even then, as noted above, a coefficient of 0.5683 may be statistically significant, but empirically it does not rule out other possible explanations.

1. Comparing CNMI and Hawaii: Download/Upload Speeds

The people of CNMI and Hawaii experience strikingly different advertised download/upload broadband speeds. As Table 8 shows, the Hawaiian means for the low and high end of the maximum advertised *download* speed range are significantly higher than advertised speeds reported for CNMI (the mean differences are 1.09 Mbps and 3.86 Mbps, respectively), as are the low and high end of the maximum advertised *upload*

Table 8

Two-Sample Welch's t-Tests of BroadMap Variables:

Means for Commonwealth of the Northern Mariana Islands – (minus) Means for Hawaii

BroadMap Variable	Combined Obs.	μ(CNMI) - μ(Hawaii)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Number of ISPs	2785	-1.189506	1447.44	-0.11	0.0000	0.0000	1.0000
Minimum of the Maximum Advertised Download Speed Range	2785	-0.0859474	816	-2.555	0.0054	0.0108	0.9946
Maximum of the Maximum Advertised Download Speed Range	2785	-2.831141	1093.66	-70.4523	0.0000	0.0000	1.0000
Minimum of the Maximum Advertised Upload Speed Range	2785	0.3621958	874.232	8.9122	1.0000	0.0000	0.0000
Maximum of the Maximum Advertised Upload Speed Range	2785	-0.599948	816	-20.4212	0	0	1

speed range (the mean differences are 1.44 Mbps and 3.58 Mbps).[47] The high end of the maximum advertised *upload* speed range (the mean difference is 3.76 Mbps).

[47] Note that these mean differences are exponentiations of the logarithms in Table 8 and therefore represent the actual mean differences in advertised speeds. Column 2 of Table 8 is showing the logarithmic difference, since the datasets were logarithmically transformed, which then were converted (exponentiated) in order to derive the actual numbers presented in the text that can be interpreted empirically.

Table 2

Median Advertised Speed, Download/Upload by Carrier Type, Census District and Road Segment Layers, U.S. Pacific Territories

	Type	Maximum Advertised Speed DOWN (Mbps)		Maximum Advertised Speed UP (Mbps)	
		Census District Layer	Road Segment Layer	Census District Layer	Road Segment Layer
American Samoa	All	$0.768 \leq s < 1.5$	$0.768 \leq s < 1.5$	$0.200 \leq s < 0.768$	$0.200 \leq s < 0.768$
	ADSL	$0.768 \leq s < 1.5$	$0.768 \leq s < 1.5$	$0.200 \leq s < 0.768$	$0.200 \leq s < 0.768$
	Cable	$1.5 \leq s < 3$	-	$0.200 \leq s < 0.768$	-
CNMI	All	$1.5 \leq s < 3$	$1.5 \leq s < 3$	$0.768 \leq s < 1.5$	$0.768 \leq s < 1.5$
	ADSL	$1.5 \leq s < 3$	$1.5 \leq s < 3$	$0.768 \leq s < 1.5$	$0.768 \leq s < 1.5$
	Cable	$1.5 \leq s < 3$	-	$0.200 \leq s < 0.768$	-
Guam	All	$6 \leq s < 10$	$6 \leq s < 10$	$1.5 \leq s < 3$	$1.5 \leq s < 3$
	ADSL	$6 \leq s < 10$	$6 \leq s < 10$	$1.5 \leq s < 3$	$1.5 \leq s < 3$
	Cable	$10 \leq s < 25$	$10 \leq s < 25$	$1.5 \leq s < 3$	$1.5 \leq s < 3$
	Copper	$1.5 \leq s < 3$	$1.5 \leq s < 3$	$1.5 \leq s < 3$	$1.5 \leq s < 3$
	SDSL	$6 \leq s < 10$	$1.5 \leq s < 3$	$1.5 \leq s < 3$	$1.5 \leq s < 3$

Source: BroadMap

1. Comparing CNMI with American Samoa and Guam: Download/Upload Speeds

Guam has a higher range of maximum advertised download speeds than the CNMI, as well as a higher maximum advertised upload speeds.[48] Table 2 (just above) shows the ranges of median maximum advertised download and upload speeds for each of the three U.S. Pacific Territories:[49]

Table 3 provides similar information for wireless broadband providers:

Table 3
Wireless Broadband Providers and Maximum Advertised Download and Upload Speeds Per ISP Per Territory

Wireless Providers	Location	Maximum Advertised Download Speed (Mbps)	Maximum Advertised Upload Speed (Mbps)
AST Telecom, LLC	American Samoa	$3 \leq s < 6$	$0.768 \leq s < 3$
PTI Pacifica Inc.	CNMI	$3 \leq s < 6$	$0.768 \leq s < 3$
Docomo Pacific	Guam	$1.4 \leq s < 3$	$0.768 \leq s < 3$
PTI Pacifica Inc.	Guam	$1.4 \leq s < 3$	$0.768 \leq s < 3$

Source: BroadMap

Appendix 3, Tables 4 and 5 show that CNMI's advertised *download* speeds are higher than American Samoa by 0.165 Mbps (at the low end) and 0.209 Mbps (at the high end) of the maximum

[48] See Appendix 3, Tables 4-5.
[49] These are drawn from both the census block layer and the road segment layer for each territory. However, because the road segment layer is not provided by NTIA in the National Broadband Map data for Hawaii, Puerto Rico, and the U.S. Virgin Islands, it is not included in the comparative analyses.

advertised range, respectively; and between 0.306 Mbps and 0.277 Mbps slower than Guam at the low and high end of the maximum advertised range, respectively. The high end of Guam's maximum advertised *upload* speeds is also higher than either American Samoa or the CNMI. CNMI's advertised upload speeds are higher than American Samoa by 0.144 Mbps and 0.206 Mbps – the low and high ends of the maximum advertised range, respectively; and between 0.369 Mbps and 0.543 Mbps slower than Guam at the low and high end of the range, respectively.[50]

2. Comparing CNMI with Puerto Rico: Download/Upload Speeds

The differences in the quality of the advertised speeds between CNMI and Puerto Rico are far less striking than those between CNMI and Hawaii. The bottom of the range of advertised download and upload speeds in CNMI is significantly higher, but the top range of both advertised download and upload is slower in CNMI than Puerto Rico.[51]

3. Comparing CNMI with U.S. Virgin Islands: Download/Upload Speeds

The same pattern emerges for the CNMI and the USVI as for Puerto Rico: CNMI has better low end of the advertised download and upload ranges, while USVI has better high end of those ranges. [52]

C. Final Tests of the ISP-Reported Data

[50] As explained in footnote 22, these mean differences are exponentiations of the logarithms in Table 8 and therefore represent the actual mean differences in advertised speeds. Column 2 of Tables 4 and 5 is showing the logarithmic difference, since the datasets were logarithmically transformed, which then were converted (exponentiated) in order to derive the actual numbers presented in the text that can be interpreted empirically.
[51] See Appendix 3, Table 10.
[52] See Appendix 3, Table 12.

It is possible that the small size of the datasets are somewhat exaggerating the degree of difference between Hawaii, the U.S. Pacific Territories, Puerto Rico, and the U.S. Virgin Islands. To provide more precise estimates of difference, an analysis of covariance (ANCOVA) can be performed – an ordinary least squares regression[53] on a variable using only dummy variables for the tested groups (in this case the various territories). An ANCOVA is mathematically equivalent to an analysis of variance without the equality-of-variances assumption. The results of running an ANCOVA the number of wireline ISPs are shown in Table 14, which is calculated using all the data in all of the location datasets:

Table 14

Analysis of Covariance: Number of Wireline ISPs, U.S. Pacific Territories, Hawaii, Puerto Rico and U.S. Virgin Island Dataset

Number of obs. = 18589	R-squared = 0.8178
F(5, 18583) =16685.31	Adj. R-squared = 0.8178
Prob > F = 0.0000	Root MSE = 0.1112

Number of ISPs	Coef.	Std. Err.	T	P>|t|
American Samoa	-1.112155	0.0056175	-197.98	0.0000
Commonwealth of Northern Marianas Islands	-1.189506	0.004628	-257.02	0.0000
Guam	-0.667108	0.0039974	-166.89	0.0000
Puerto Rico	-0.4541732	0.0076903	-59.06	0.0000

53 See Appendix 1.

U.S. Virgin Islands	-0.667108	0.0108711	-61.37	0.0000
Constant	1.76572	0.0038904	453.87	0.0000

The coefficients in an ANCOVA are measures of the similarity between groups and a negative coefficient indicates an association with lower amounts of the wireline ISPs dependent variable. Guam and the U.S. Virgin Islands are most similar (-0.677108), and are in the mid-range of number of wireline ISPs. American Samoa (-1.112155) and the CNMI (-1.189506) are also similar, but have fewer wireline ISPs. Puerto Rico (-0.4541732) has the largest number of ISPs among the U.S. Territories, although by comparison to Hawaii is, like the other territories, negatively-signed, indicating Hawaii's significantly larger number of ISPs.

Although there is no doubt that the tested demographic, social and economic differences between the territories are significant, this analysis of covariance suggests that the territories are more similar than the t-tests indicated. It is merely a commonplace in statistical analysis that very large sample size will increase the mathematical significance of differences found.

It was also possible to run the entire dataset (Guam, American Samoa, CNMI, Hawaii, Puerto Rico, and USVI) with the number of wireline ISPs as the dependent variable while including an additional independent variable beyond the census variables: distance from territory capital to nearest U.S. state capital in miles. The new model suggests that there is also some spatial relationship between how far ISPs must go to deploy hardware. The results are shown in Table 15:

Table 15

OLS Regression of Census Variables on Number of Wireline ISPs:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 18144	R-squared = 0.9535
F(11,18132) = 33742.60	Adj R-squared = 0.9534
Prob > F = 0.0000	Root MSE = 0.05501

Number of ISPs	Coef.	Std. Err.	t	P>|t|
Distance	-0.000039	0.000125	-31.23	0.0000
Total Population	0.1292844	0.0010622	121.71	0.0000
Percent Ethnically Hawaiian	-0.1477702	0.0020391	-72.47	0.0000
Percent Ethnically Caucasian	0.1953585	0.0014482	134.9	0.0000
Percent with High School Degree or Higher	2.503465	0.0242733	103.14	0.0000
Percent with Bachelor Degree or Higher	0.4387525	0.0041944	104.6	0.0000
Percent of Workforce Employed	0.455117	0.0047729	95.35	0.0000
Percent in Agricultural Industry	-0.0765598	0.0010708	71.5	0.0000
Per Capital Income	0.9656339	0.0053552	180.32	0.0000
Percent of Families At or Below the Poverty Level	-0.2040469	0.0023497	86.84	0.0000
Percent of Homes Without Telephone Service	-0.1415764	0.0020505	69.04	0.0000
Constant	3.595941	0.1111263	32.36	0.0000

The education and prosperity variables are appropriately signed (positive), as are the indices of rurality and poverty (negative). The distance coefficient, while small, is highly significant and appropriately signed (negative, meaning that the shorter the distance, the higher the number of wireline ISPs), and does suggest that costs of deploying from Hawaii or the continental U.S. do play a role in determining number of wireline ISPs, explaining in part the relatively larger number of providers in Puerto Rico and the U.S. Virgin Islands.

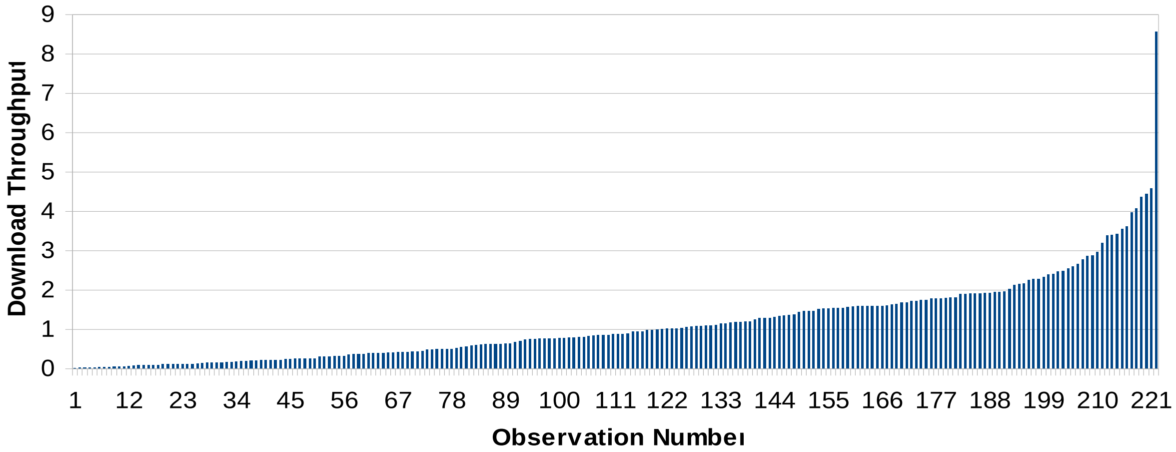
III. M-Lab Measurements: Comparing Actual Broadband Speed and Other Performance Results

There are real and substantial differences between what incumbent ISPs advertise as the maximum and minimum download/upload speeds in CNMI and what consumers actually experience on a day-to-day basis. But while "advertised" speeds are self-reported and published by NTIA on the National Broadband Map, it remains critical to know whether advertised speeds reflect typical real-time performance speeds. The Measurement Lab (M-Lab) test data analyzed for this study appear to confirm that they do not. In short, there are striking differences between advertised download/upload speeds self-reported by CNMI's ISPs and the results of actual speed tests run by individuals over a 32-month period through August 2012. The broadband user test results analyzed below were collected monthly for the U.S. Pacific Territories, Hawaii, Puerto Rico, and the U.S. Virgin Islands from January 1, 2010 through August 20, 2012. The monthly results can be seen in Appendix 4, which also includes results from the state of Mississippi, as another point of comparison.[54] Tables detailing the statistical analyses are in Appendix 5.

[54] Logarithmic transformation of the M-Lab data was not performed owing to the occurrence of natural zero values in the M-Lab data.

It is useful to keep in mind how download and upload throughput are measured: they are the medians of a distribution of the maximal value of each for each IP number testing during the month. For example, Figure 1 shows the histogram of the frequency distribution of download throughput maxima for May 2012 for Guam:

Figure 1. Download Throughput Histogram, May 2012



In this sample histogram for Guam, it should also be noted that there are relatively large numbers of outlier observations at either end of the distribution around the median of 0.88 Mbps.

Wireline ISPs in CNMI advertise maximum ***download*** speeds in the 1.5-to-3 megabits per second (Mbps) range. All wireline ISPs in CNMI advertise maximum ***upload*** speeds in the 0.200-0.768 Mbps range. Yet, the M-Lab tests for CNMI register a median monthly download throughput that averages 0.310 Mbps and a median monthly upload throughput that averages 0.210 Mbps over the period from January 2010 through August 2012.[55] It is important to note that just subsequent to the end of this measurement period, in September 2012, the provider IT&E in CNMI substantially upgraded the

[55] See Appendix 4.

speeds for their DSL plans.[56] Since the regressions and correlations below were done with data averaged over the 30 months prior to this, they do not take into account IT&E increasing speeds after September 1, 2012.

Some added caution must be taken in relying on the precise magnitude of this gap between reported and actual measured download/upload throughput. M-Lab data are likely underreporting real-time speeds for two reasons. First, the initial monthly sample sizes were quite small, and therefore less robust. Since tests are voluntary and initiated by consumers, in a small sample a disproportionate participation by subscribers of a slower technology (e.g., the relative mix of cable and DSL) could result in a low median. On the other hand, well before the conclusion of the examined period the sample sizes for Guam were approximating the 200 observations-per-month threshold that Google (an M-Lab co-sponsor) uses to determine whether to make monthly test data for a geographic jurisdiction available to researchers and/or the public. The M-Lab data for the U.S. Pacific Territories analyzed here are therefore unpublished, since even aggregated the monthly totals do not aggregate to more than 200 observations per month on average. The situation is similar for Puerto Rico and the U.S. Virgin Islands, where monthly observations also fall short of the recommended 200 tests per month. Despite this smaller number of measurements (compared to each of the 50 states, for example), the M-Lab results for CNMI and the other U.S. territories are robustly consistent, which offers greater confidence in their relative accuracy and usefulness for correlation and regression analysis.

A second more technical reason that M-Lab tests may understate actual connection speeds is the greater physical distance between CNMI and the nearest M-Lab monitoring servers. This can attribute negative network performance to a matter of relative geography, which has been observed as a

[56] *See* http://www.pticom.com/news_and_info.cfm?vzid=40

problem with the NDT protocol more generally.[57] The U.S. Pacific Territories and Hawaii are physically farther from M-Lab servers than most other M-Lab clients running tests. On the other hand, a factor that should mitigate concern about the significance of this second explanation is the fact that Puerto Rico and the U.S. Virgin Islands, both much closer to M-Lab servers on the U.S. mainland, scored results remarkably similar to CNMI (and, as we will see, their similar demographic profile fit with explanations of a wide broadband performance gap). There is also the fact that the M-Lab data closely correlate to the census demographic variables – and regressions on those M-Lab variables identify robust coefficients and are accounted for with very high coefficients of determination. These are not the statistical characteristics of chimera – the U.S. island territories in general have consistently lower measured download/upload speeds than the rest of the nation and roughly in proportion to demographic disadvantage. However, even granting these potential objections, it is extremely unlikely that a significant increase in download or upload throughput would be observed if one could control for both factors.

BroadMap collected a small number of voluntary, real-time speed tests in May 2012 in Guam which may help to clarify the situation. While sample sizes are too small for statistical analysis, the means and standard deviations for such tests are interesting: for ADSL technology the mean download speed was 1.407 Mbps (standard deviation = 0.727) for ten observations; and for cable modem technology the mean download speed was 3.567 Mbps (standard deviation = 3.126) for five observations. For ADSL technology the mean upload speed was 0.776 Mbps (standard deviation = 0.374) for 10 observations; for cable modem technology the mean upload speed was 1.494 Mbps (standard

[57] The Network Diagnostic Tool (NDT) collects Web100variables data which is used to calculate measures of download/upload speeds, latency (delay) and jitter (variation in delay). NDT variables measure **the actual, real-time Internet performance** of testers' Internet connections. NDT is used widely in Internet speed test measurements, including by M-Lab and the extensive measurement data collected and published by the Federal Communications Commission – which itself has relied on the M-Lab server platform along with one other commercial provider.

deviation = 0.895) for five observations. [58] These speeds are substantially less than the advertised download/upload speeds for Guam, although somewhat higher than the M-Lab findings.

After comparing CNMI's measured performance over the 32-month period with the other territories and the state of Hawaii, this section concludes by analyzing the relationship between demographic variables and the six M-Lab performance metrics (two related to throughput/speed and four related to latency/delay). Appendices 4 and 5 present these findings in detail.

Regressions on the M-Lab performance variables substantially confirm that urbanization, higher economic status, and Caucasian ethnicity are strongly associated with better actual broadband speeds and quality of service; and that rurality, lower economic status, and non-white ethnicity are associated with lower levels of measured broadband quality. The results are particularly troubling since they indicate that absent public policy interventions aimed at offsetting demographic disadvantages – particularly low household income, rurality, education and ethnic minority status – most of the population of CNMI and the other U.S. Pacific Territories, as well as Puerto Rico and the U.S. Virgin Islands, may be permanently condemned to inferior broadband service for intractable economic and sociological reasons.

A. Measurement Lab: Background

The Measurement Lab (M-Lab) is an open, distributed and global platform of servers for researchers to deploy Internet measurement tools, including basic consumer diagnostic tests that measure real-time download and upload throughput (connection "speeds") along with a host of other performance metrics. M-Lab was established and is

[58] One problem is that BroadMap does not always report which technology is being tested; cases where that data is not available are not discussed here.

Defining the M-Lab Variables

Download throughput ("speed") is estimated by an NDT test which measures the maximum amount of data that can be transferred from an M-Lab server to the user's device within a defined period of time. The higher the value of download throughput, the better is the download speed performance experienced.

Upload throughput ("speed") is estimated by an NDT test which measures the maximum amount of data that can be transferred from a user's device to the M-Lab server within a defined period of time. The higher the value of upload throughput, the better is the upload speed performance experienced.

The ***Round Trip Time (RTT)*** of a client during a specific month is estimated as the minimum RTT of all the tests run by that client during that month. The lower the RTT value, the lower the latency exhibited.

In testing network and server limitations NDT attempts to create congestion between a user's machine and the M-Lab server and, as a consequence, while running a test can be in three states: ***Network-Limited, Client-Limited, and Server-Limited***. NDT tests are never server-limited on an M-Lab platform. Therefore, each test expends some ratio of the test time in a network-limited state or a client-limited state. A test is in network limited state when the throughput is limited by congestion in the network. On the other hand, a test is in receiver-limited state when the user's device limits the throughput. In general, it is better to have a lower network-limited time ratio, since that indicates less latency in the network

The ***weighted received window scale*** is the value negotiated at the beginning of a TCP connection to scale the receiver window size. The ***received window size*** is the maximum amount of received data that can be buffered at one time on the receiving side of a TCP connection.

operated through a collaboration among New America Foundation's Open Technology Institute, Google Inc., as well as the PlanetLab Consortium at Princeton University and additional contributions from academic researchers. M-Lab deploys five network tools that collect data testing Internet performance. One of these, the **Network Diagnostic Tool (NDT)**, collects Web100 variable data which are used to calculate measures of download/upload speeds, latency (delay) and jitter (variation in delay). NDT variables measure **the actual, real-time performance** of testers' Internet connections. The relevant measures for our purposes are connection speed – download and upload throughput-- and measures of connection delay – round trip time, network-limited time ratio, client-limited time ratio, and weighted receiver window scale. There is a detailed discussion of each variable and explanation of how it is calculated in Appendix 1.

B. The Broadband Performance Gap: A Comparative Overview

The M-Lab test data provide vital insight into the real world of Internet connection performance. While the analysis below focuses on the differences between measured download/upload speeds and other performance metrics for the U.S. Pacific Territories, Hawaii, Puerto Rico, and the U.S. Virgin Islands, it is both helpful and sobering to compare the actual performance measured for these geographic locations with those for various European countries, as well as those for the U.S. generally. This comparison is seen in Table 16, which presents mean values for the months from January 1, 2010 to April 30, 2012, in the case of the nations, and updated through August 2012 for CNMI and the other U.S. territories with respect to download and upload throughput (the other M-Lab metrics are through April 2012 for all locations).

Table 16

Comparison of M-Lab Metrics

	Albania	Belarus	Bosnia-Herzegovina	U.S.	Netherlands	Belgium
Download Throughput (Mbps)	0.58	0.68	1.13	4.91	7.42	5.23
Upload Throughput (Mbps)	0.23	0.31	0.15	0.78	0.75	0.67
Round Trip Time	127	125	83	35	21	33
Network-Limited Time Ratio	0.96	0.88	0.91	0.67	0.3	0.4
Client-Limited Time Ratio	0.14	0.11	0.08	0.32	0.7	0.59
Weighted Receiver Scale	1.16	1.03	1.25	2.67	2.64	2.72

	American Samoa	Commonwealth of the Northern Marianas Islands	Guam	Puerto Rico	U.S. Virgin Islands	Hawaii
Download Throughput (Mbps)	0.52	0.31	0.75	1.38	0.61	3.46
Upload Throughput (Mbps)	0.38	0.21	0.33	0.34	0.46	0.72
Round Trip Time	219.07	327.68	271.46	78.19	101.25	78..89
Network-Limited Time Ratio	0.23	0.33	0.84	0.36	0.04	0.86
Client-Limited Time Ratio	0.23	0.4	0.1	0.37	0.04	0.12
Weighted Receiver Scale	1.25	1.62	2.29	1.88	1.79	2.73

Several striking facts emerge from this table:

• **Broadband speeds and other performance measurements in CNMI is generally inferior to Albania, Belarus, and Bosnia-Herzegovina, which are among the least developed**

nations in Eastern Europe.

• While the metrics for Hawaii are inferior to those of the U.S. generally, they are vastly superior to those of CNMI and the other U.S. territories.

Clearly CNMI and the other territories are disadvantaged by broadband connectivity that is starkly inferior to the continental United States and to the more developed nations of the world more broadly. These facts inform our examination of the real differences between our cases and, as we shall see, tentative explanations of the differences between the U.S. Pacific Territories, Puerto Rico, and the U.S. Virgin Islands on the one hand, and Hawaii on the other, will emerge in the form of the ethnic composition, lesser prosperity, greater poverty and greater rurality of one set of locations in contrast to the other. The M-Lab data provide stark evidence of, broadly, two levels of Internet connectivity in the U.S. and its territories: an Internet privileged by relative affluence and urbanization in most areas of the 50 states, and an Internet throttled by race, poverty and rurality in U.S. territories.

Equally important is what the M-Lab data reveal about the maximum advertised download and upload speed data provided by incumbents to the National Broadband Map contractors. In CNMI, the maximum advertised download speed self-reported by ISPs ranges from 0.768 Mbps to 3 Mbps – while the average measured download speed for M-Lab tests originating in CNMI is 0.310 Mbps. The maximum advertised upload speed for CNMI is 0.200 Mbps to 0.768 Mbps, while the mean measured upload speed for M-Lab tests originating in CNMI is 0.210 Mbps. These differences alert us to delivery of lower levels of service than advertised.

The gap between advertised and actual connectivity is similar to the other U.S. Pacific Territories. In Guam, the maximum advertised download speed self-reported by ISPs ranges from 1.4 Mbps to 10 Mbps (and even as high as 25 for cable) – speeds similar to those advertised in affluent suburbs of cities like Chicago and Dallas – while the mean measured download speed for M-Lab tests originating in Guam averages 0.750 Mbps.[59] The maximum advertised download speed ranges for American Samoa is 0.768 Mbps to 3 Mbps, while the measured download speed for M-Lab tests originating in American Samoa averages 0.520 Mbps; the maximum advertised upload speed for American Samoa is 200 kbps to 1.5 Mbps, while the mean measured upload speed for M-Lab tests originating in for the American Samoa is 0.380 Mbps, near the low end of the advertised range.

As noted above, even if the relatively small sample size available for the territories resulted in an under-estimation of speed by an order of magnitude (which is extremely unlikely), actual users in the U.S. Pacific Territories do not experience the advertised maxima, at least not on a consistent basis. **As far as the territories are concerned, the advertised maximum speeds bear little relationship to user experience or functionality in practice. This raises serious questions concerning whether the U.S. government is collecting and publishing ISP performance data which presents a distorted and overly optimistic impression of the broadband service available to the people of CNMI and the other U.S. territories.**

C. The Correlation Matrix: Links Between Demographics and Broadband Quality

A correlation matrix was calculated for all the M-Lab variables and for the natural logarithms of the census variables for CNMI, the other two U.S. Pacific Territories, Hawaii, Puerto Rico and the U.S. Virgin Islands. Correlations were run to examine, for example, the degree to which differences in actual download speeds could be explained by demographic variables such as median household

[59] See Appendix 3, Table 2.

income, education and rurality. All these cases were aggregated to ensure the most robust result.[60] The detailed results can be seen in Appendix 5.

The correlations are remarkably strong and robust at high significance levels. Unlike many of the self-reported ISP variables for speeds analyzed in the previous section of this report (e.g., advertised download/upload speeds), which were typically reported as uniform island-wide, the actual measurement data correlate to the real world. The most significant correlations are summarized for various M-Lab performance metrics. Results listed are variable correlation coefficients where values range from -1.0 to 1.0. A value of 1.0 indicates perfect correlation, a value of -1.0 indicates perfect inverse correlation, and a value of 0.0 indicates no correlation.

1. Download Speeds

First, **there is a high correlation between download throughput and upload throughput (0.9865),** which is an expected artifact of the pairing of download/upload rates in commercially marketed packages by ISPs. While such rates often represent idealized maxima (and in the case of the U.S. Pacific Territories, as well as other areas, actual performance falls drastically short of these maxima), the ratio of download to upload bandwidth is a relative constant for any particular ISP, regardless of the level of actual delivery.

Second, **we find clear positive correlations of the download throughput variable with measures of prosperity**: median household income (0.6560), mean household income (0.7799), and per capita income (0.5849). There is a similarly strong correlation between download speeds and education:

[60] A correlation matrix was calculated for the M-Lab variables and the natural logarithms of the census variables. T-tests were run comparing the M-Lab variables over the aggregated U.S. Pacific Territories, the individual territories, Hawaii, Puerto Rico and the U.S. Virgin Islands. Utilizing this matrix and the t-tests of census data reported above variables were selected for regressions on the M-Lab variables.

percent of population with a high school degree or higher (0.7054) and percent of population with a bachelor degree or higher (0.4544). There are weaker but still positive relationships between download throughput and total population (0.4051) and median age (0.4236).

Third**, strong negative relationships are found between download throughput and indices of both poverty** (percent of families at or below the poverty level, -0.8010, and percent of families with female heads of household, -0.8492) and rurality (percent of homes without telephone service, -0.7282). Likewise there is a very strong negative correlation with percent of population of Hawaiian ethnicity (-0.8391).

2. Upload Speeds

Correlations for upload throughput parallel those of download throughput, only somewhat stronger by and large. The positive association with the income variables are stronger – median household income, 0.6701, mean household income, 0.7924, and per capita income, 0.5896)-- while those with total population (0.3708), median age (0.4062), percent of population with high school degree or higher (0.5010) and bachelor degree or higher (0.4380) are slightly weaker. Stronger negative correlations coincide with percent of population of Hawaiian ethnicity (-0.8458), metrics of poverty (percent of families at or below the poverty level, -0.8135, and percent of families with female head of household at or below poverty level, -0.8675) and a proxy for rurality (percent of homes without telephone service, -0.7401) are observed.

3. Latency

Round trip time (where a higher value is indicative of greater latency) is negatively correlated with total population (-0.6471), median age (-0.5930), percent of population ethnically Caucasian (-0.7371), percent of workforce engaged in financial industry (-0.5760), and percent of population engaged in education (-0.7211). It is positively correlated (i.e., greater latency) with percent of population ethnically Hawaiian (0.4369) and percent of homes without telephone service (0.4221). Counter-intuitively, it is also positively correlated with percent of workforce employed (0.5904).

Network-limited time ratio, much like the throughput (speed) variables, is positively correlated with, percent of population with high school degree or better (0.9006) or a bachelor degree or better (0.4981), percent of workforce engaged in information industry (0.6265) or financial industry (0.4429), and the income indicators – median household income (0.7661), mean household income (0.7439, and per capita income (0.4681). It is negatively correlated with percent of population ethnically Hawaiian (-0.5560), the poverty metrics (-0.6775 and -0.6450, respectively), and percent of homes without telephone service (-0.5747).

Client-limited time ratio is only moderately positively correlated with percent of homes without telephone service (0.5347); it is moderately negatively correlated with percent of population male (-0.4077), percent of workforce engaged in public administration (-0.5158) and median household income (-0.4331), while more strongly correlated with percent of households with female heads (-0.5917).

Weighted received window scale, much like the throughput (speed) variables, positively correlates with median age (0.4691), percent of population with a bachelor degree or higher (0.5653), percent of workforce engaged in financial industry (0.5078) or the professions (0.5390), and the income variables (0.4576, 0.4946, and 0.5630, respectively). It negatively correlates with percent of population ethnically Hawaiian (-0.5501), the poverty metrics (-0.5198 and -0.4796, respectively), and percent of homes without telephone service (-0.4855).

D. Comparing CNMI's Performance Metrics to the Other Territories and Hawaii

This section summarizes how CNMI's average measured performance on six M-Lab test metrics compare to the other U.S. territories and Hawaii. Appendix 5, Tables 17 to 22 correspond to each of the M-Lab metrics, providing statistical detail.

1. Download Speeds

In terms of download throughput, the mean for CNMI was significantly lower than the other states and territories on which analysis was performed, although the results were less robust for the comparison with American Samoa.[61]

2. Upload Speeds

Results show that CNMI significantly underperforms all other territories and states examined in this study in mean upload throughput.[62] Again, the comparison between CNMI and American Samoa is slightly less robust.

3. Latency

Round Trip Time is a measure of server-client latency and the lower the mean value, the less latency in the system. CNMI has higher round trip times than all the other states and territories examined in the study.[63]

[61] See Appendix 5, Table 17.
[62] See Appendix 5, Table 18.
[63] See Appendix 5, Table 21.

Network-Limited Time Ratio: CNMI has a significantly lower mean network-limited time ratio than Guam, Puerto Rico, and the Hawaii.[64] However, the U.S. Virgin Islands' and American Samoa's network-limited time ratio are lower than that of CNMI.

Client-Limited Time Ratio, CNMI has a higher mean client-limited time ratio than all other states and territories examined in this study.[65]

Weighted Received Window Scale is a measure of one of the principal constraints on tested machine performance set by the network. If the network specifies a lower received window scale than the rate the computer running the test can actually buffer, it will generate latency. Generally a higher weighted received window scale is preferable to a lower one. CNMI has a lower mean weighted receiver window scale than all the other cases except for American Samoa.[66]

E. Explaining the Differences: The Relationship between Demographic Variables and M-Lab Results

Which differences between geographic locations are most significant and which census variables are most explanatory of the M-Lab outcome variables? Again, we turn to regression in pursuit of an answer to both. The analysis was conducted over the entire dataset – Guam, American Samoa, CNMI, Hawaii, Puerto Rico, and the U.S. Virgin Islands – to observe all the variation in relationships between M-Lab and census variables. All census variables with a correlation to a particular M-Lab variable greater than or equal to an absolute value of ± 0.40 and census variables with statistical significance are included in the initial equation. Dummy variables for all six

[64] See Appendix 5, Table 19.
[65] See Appendix 5, Table 20.
[66] See Appendix 5, Table 22.

jurisdictions – the U.S. Pacific Territories, Hawaii, Puerto Rico and the U.S. Virgin Islands – are included as well. [67]

1. Download Speed

The results of the regression on download throughput can be seen in Appendix 5, Table 23. All dummy variables except that for Hawaii (hw) were dropped for statistically insignificant absolute value of t, indicating that the difference between Hawaii and all the remaining territories is overwhelmingly the most important of any of the tested differences between locations over the download throughput variable. Total population, percent of population of Caucasian ethnicity, percent of population with a bachelor degree or higher, and per capita income are positively signed. Percent of population ethically Hawaiian, percent of workforce engaged in agricultural industry, and percent of homes without telephone service are negatively signed.

[67] An alpha (α)≤ 0.10 was used to determine the statistical significance of all variables.

Table 23

OLS Regression of Census Variables on Download Throughput, U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135	R-squared = 0.9772
F(8,129) = 5214.60	Adj R-squared = 0.9763
Prob > F = 0.0000	Root MSE = 0.18654

Download Throughput	Coef.	Std. Err.	t	P>|t|
Hawaii	3.018828	0.1537104	19.64	0
Total Population	2.117983	0.0731723	28.95	0
Percent Ethnically Hawaiian	-0.1576326	0.0538191	-2.93	0
Percent Ethically Caucasian	0.1431909	0.0157993	9.06	0.004
Percent with Bachelor Degree or Higher	1.043963	0.1482194	7.04	0
Percent in Agricultural Industry	-1.222567	0.0245672	-49.76	0
Per Capital Income	1.094507	0.0836963	13.08	0
Percent of Homes Without Telephone Service	-0.8485853	0.0389359	-21.79	0
Constant	-8.113577	0.8401439	-9.66	0

It is particularly noteworthy that the regression accounts for 97.63 percent of the variation in the outcome variable. Interpreting these results is straightforward:

• indices of urbanization indicate higher values for download throughput, hence higher download speeds;

• indices of rurality – such as percent of workforce engaged in agricultural industry and percent of homes without telephone service – indicate lower values for download throughput, hence lower download speeds;

• higher levels of education in a population – such as percent of population with a bachelor degree or better – indicate higher values for download throughput;

• higher per capita income indicates higher values for download throughput;

• race and ethnicity appear to matter: the higher the percent of population that is ethnically Caucasian, the higher the download throughput values, while the higher the percent of population that is ethnically Hawaiian, the lower the values of download throughput.

2. Upload Speeds

The results of the regression on upload throughput are remarkably similar, as shown in Table 24 just below. Again, all dummy variables were dropped for statistically insignificant absolute values of t except Hawaii, indicating that the difference between Hawaii and all the remaining territories is overwhelmingly the most important of any of the tested differences between locations over the upload throughput variable. Once more, patterns seen in regressions on number of wireline ISPs above emerge here in the independent variables which met the appropriate significance level for the absolute value of t. Total population, percent of population of Caucasian ethnicity, percent of population with a bachelor degree or higher, and per capita income are positively signed, meaning predicting higher upload speeds. Percent of population ethically Hawaiian, percent of workforce engaged in agricultural industry, and percent of homes without telephone service are negatively signed, meaning predicting lower upload speed.

Table 24

OLS Regression of Census Variables on Upload Throughput, U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135	R-squared = 0.9955
F(8,129) = 5714.57	Adj R-squared = 0.9953
Prob > F = 0.0000	Root MSE = 0.01507

Upload Throughput	Coef.	Std. Err.	T	P>|t|
Hawaii	0.5957845	0.0285517	20.97	0
Total Population	0.0467319	0.0022395	20.87	0
Percent Ethnically Hawaiian	-0.0545381	0.0051645	-10.56	0
Percent Ethically Caucasian	0.0327859	0.0015712	20.87	0
Percent with Bachelor Degree or Higher	0.1372457	0.0147901	9.28	0
Percent in Agricultural Industry	-0.2684751	0.0024127	-111.28	0
Per Capital Income	0.1241279	0.0150977	8.22	0
Percent of Homes Without Telephone Service	-0.1755959	0.003843	-45.69	0

_Constant	-0.9613414	0.1145519	-8.39	0

It is noteworthy that the regression accounts for 99.53 percent of the variation in the outcome variable. Interpreting these results is intuitive and parallels the findings for download throughput, noted just above:

• indices of urbanization, such as total population, indicate higher values for upload throughput;

• indices of rurality – such as workforce engaged in agricultural industry and percent of homes without telephone service – indicate lower values for upload throughput;

• higher levels of education and higher per capita income indicate higher values for upload throughput;

• race and ethnicity appear to matter: the higher the percent of population ethnically Caucasian, the higher the upload throughput values, while the higher the percent of population ethnically Hawaiian, the lower the values of upload throughput.

3. Round Trip Time

Table 25 presents the results of the regression on round trip time:

Table 25
OLS Regression of Census Variables on Round Trip Time:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135	R-squared = 0.8709
F(7,129) = 174.12	Adj R-squared = 0.8659
Prob > F = 0.0000	Root MSE = 0.03842

Round Trip Time	Coef.	Std. Err.	t	P>|t|
Hawaii	1767.632	72.82186	24.97	0.0000
Total Population	-138.6487	5.711969	-24.27	0.0000
Percent Ethnically Hawaiian	-97.27254	4.007377	-24.07	0.0000
Percent with Bachelor Degree or Higher	-1140.695	60.28005	-18.92	0.0000
Percent in Agricultural Industry	84.88094	8.204811	10.35	0.0000
Per Capital Income	-874.5169	54.31897	-16.1	0.0000
Percent of Homes Without Telephone Service	97.39264	11.676	8.34	0.0000

Constant	7018.056	425.6195	16.49	0.0000

Here the results are inversely signed to those for download and upload throughput, as would be expected, since the higher the value of round trip time, the greater the latency, while the higher the value of download and upload throughput, the better performance of the Internet connection. Dummy variables except for Hawaii were dropped for statistically insignificant absolute value of t, indicating that the difference between Hawaii and all the remaining territories is overwhelmingly the most important of any of the tested differences between locations over the round trip time variable. Total population, percent of population with a bachelor degree or higher, and per capita income are negatively signed. Percent of population ethically Hawaiian, percent of workforce engaged in agricultural industry, and percent of homes without telephone service are positively signed.

Note that the regression accounts for 86.59 percent of the variation in the outcome variable. Interpreting these results is straightforward:

• indices of urbanization, like total population, indicate lower values for round trip time;

• indices of rurality – such as percent of workforce engaged in agricultural industry and percent of homes without telephone service – indicate higher values for round trip time;

• higher levels of education and per capita income indicate lower values for round trip time;

• race and ethnicity appear still to matter: the higher the percent of population ethnically Hawaiian, the higher the values of round trip time.

4. Network-Limited Time Ratio

The results of the regression on network-limited time ratio are similar to those for download and upload throughput (Table 26 below). Once more, all dummy variables except that for Hawaii were dropped for insufficiently significant absolute value of t, indicating that the difference between Hawaii and all the remaining territories is overwhelmingly the most important of any of the tested differences between locations over the network-limited time ratio variable. Percent of population of Caucasian ethnicity, percent of population with a bachelor degree or higher, and per capita income are positively signed. Percent of workforce engaged in agricultural industry, and percent of homes without telephone service are negatively signed.

Table 26

OLS Regression of Census Variables on Network-Limited Time Ratio:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135	R-squared = 0.8839
F(6,129) = 196.45	Adj R-squared = 0.8794
Prob > F = 0.0000	Root MSE = 0.11001

Network-Limited Time Ratio	Coef.	Std. Err.	t	P>|t|
Hawaii	1.566858	0.2007521	7.8	0.0000
Percent Ethnically Caucasian	0.2289411	0.0114701	19.96	0.0000
Percent with Bachelor Degree or Higher	2.627562	0.1079713	24.34	0.0000
Percent in Agricultural Industry	-0.0493425	0.0176131	-2.8	0.0000
Per Capital Income	2.349932	0.1102171	21.32	0.0000
Percent of Homes Without Telephone Service	-0.6491278	0.0280547	-23.14	0.0000

Constant	16.87788	0.8362592	20.18	0.0000

Note that the regression accounts for a robust 87.94 percent of the variation in the outcome variable. Total population was dropped for not meeting the required significance level. Interpreting these results is obvious:

• indices of rurality – such as percent of workforce engaged in agricultural industry and percent of homes without telephone service – indicate lower values for the network-limited time ratio;

• higher levels of education and of per capita income each indicate higher values for the network-limited time ratio;

• race and ethnicity still matter: the higher the percent of population ethnically Caucasian, the higher the network-limited time ratio.

5. Client-Limited Time Ratio

The results of the regression on client-limited time ratio were not nearly so robust, as Table 27 shows:

Table 27

OLS Regression of Census Variables on Client-Limited Time Ratio:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135	R-squared = 0.3888
F(6,130) = 20.67	Adj R-squared = 0.3700
Prob > F = 0.0000	Root MSE = 0.15031

Client-Limited Time Ratio	Coef.	Std. Err.	t	P>|t|
Hawaii	-0.912377	0.1319235	-6.92	0.0000
Total Population	0.1900307	0.0257558	7.38	0.0000
Percent Ethnically Hawaiian	-0.0132572	0.0125491	-1.06	0.0000
Percent in Agricultural Industry	-0.460167	0.0618008	-7.45	0.0000
Per Capital Income	0.5898405	0.1124645	5.24	0.0000
Percent of Homes Without Telephone Service	-0.2325678	0.0254666	-9.13	0.0000
Constant	-5.202138	1.021897	-5.09	0.0000

The model accounts for only 37 percent of the variation in client-limited time ratio between CNMI and other locations. The dummy variable for Hawaii remains the only dummy retained. Total population and per capita income are positively signed. Percent of population ethnically Hawaiian, percent of workforce engaged in agricultural industry, and percent of homes without telephone service are negatively signed. In general the conclusions reached with respect to other M-Lab variables about the influence of urbanization and rurality, economic status, and race/ethnicity are confirmed, but relationships are not nearly so determinative.

6. Received Window Scale

The regression on the received window scale variable is not determinative and shares many of the same problems as that on the client-limited time ratio:

<u>Table 28</u>

OLS Regression of Census Variables on Received Window Scale:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135	R-squared = 0.3888
F(6,130) = 17.14	Adj R-squared = 0.3250
Prob > F = 0.0000	Root MSE = 0.6742

Received Window Scale	Coef.	Std. Err.	t	P>|t|
Hawaii	2.75363	0.7702111	3.58	0.0000
Total Population	0.1154815	0.0404812	2.85	0.0050
Percent in Agricultural Industry	-1.083197	0.2828021	-3.83	0.0000
Percent of Homes Without Telephone Service	-0.619044	0.2782055	-2.23	0.0280
Constant	-1.284	0.914544	-1.40	0.0630

The coefficient of determination is low (0.3250), meaning the model can explain only 32.5 percent of the variation in the latency variable. Indices of urbanization (positively signed) and rurality (negatively signed) exhibit expected directionality, but the equation fails to account for a meaningful degree of variation in the outcome variable.

In sum, regressions on the M-Lab performance variables substantially confirm that urbanization, higher economic status, and Caucasian ethnicity play significant roles in accounting for better broadband speeds and quality of service; and that rurality, lower economic status, and non-white ethnicity are associated with lower real levels of broadband quality. **These results are particularly troubling since they indicate that absent public policy interventions aimed at offsetting demographic disadvantages, most of the population of CNMI and the other U.S. Pacific Territories, as well as Puerto Rico and the U.S. Virgin Islands, may be permanently condemned to inferior broadband service for intractable economic and sociological reasons.**

F. Final Comparison: State of Mississippi

It is helpful to compare our M-Lab and U.S. Census data to Mississippi, the poorest state in the continental U.S.[68] In short, while Mississippi scores badly on socioeconomic indices in comparison to other U.S. states, including Hawaii, it does significantly better on most of them than CNMI and the other U.S. Pacific Territories.

Mississippi generally does worse on indices of wealth than does Hawaii (per capita income is $19,997 in Mississippi, compared to $21,535 in Hawaii, with 53.5 percent of workforce employed, compared to 56.6 percent for Hawaii). Mississippi, however, has a substantially higher per capita income than CNMI and the other U.S. Pacific Territories. A smaller percentage of Mississippi families are at or below the poverty level than CNMI or any other territory (although higher than Hawaii). On the other hand, the percent of workforce employed in the CNMI and Guam is higher than in Mississippi, while it is lower than Mississippi in American Samoa, Puerto Rico and the U.S. Virgin Islands.

[68] See Appendix 5, Table 35.

The results for indices of rurality are also mixed: while Mississippi is exceeded only by American Samoa in percent of workforce in agricultural industry, Mississippi is exceeded by the CNMI, American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands in percent of houses without telephone service.

Comparison of M-Lab data for Mississippi, Hawaii, and the territories conform to the expected pattern. In download throughput, Mississippi does better than all the territories, although the difference between it and Hawaii is less statistically significant.[69] For both download and upload throughput, the difference between Mississippi and the CNMI is clearly the greatest amongst the five U.S. island territories examined here. Similar results held for upload throughput, although Hawaii and the U.S. Virgin Islands scored higher than Mississippi, and the difference with American Samoa is not statistically significant.[70] In network-limited time ratio Mississippi scores higher than the other cases, although the difference with Hawaii is quite low.[71] On client-limited time ratio, Mississippi's score was lower than all cases except CNMI, although the differences with Guam and Hawaii were very small.[72] On round trip time Mississippi scored lower than all other cases, although the difference with Hawaii and Puerto Rico were smaller.[73] The weighted receiver window score for Mississippi was higher than all other cases except Hawaii.[74]

Mississippi – with its high poverty and rurality rates compared to the other U.S. states – does tend to score more closely on economic variables to the U.S. Pacific Territories, Puerto Rico, and the U.S. Virgin Islands than Hawaii, which tends to confirm the correlations between socioeconomic factors and broadband quality presented in this study. However, the shorter distances from Mississippi

[69] See Appendix 5, Table 29.
[70] See Appendix 5, Table 30.
[71] See Appendix 5, Tabl3 31.
[72] See Appendix 5, Table 32.
[73] See Appendix 5, Table 33.
[74] See Appendix 5, Table 34.

to M-Lab servers in the continental U.S. may also account, to a lesser degree, for some of its better broadband measurement performance. When it comes to broadband quality, even when a state is poor and rural it accrues advantages from merely being in the continental U.S. In sum, even the poorest and least economically developed U.S. state has better quality broadband on average than does CNMI and the other Pacific Territories.

Appendix 1: Methodology

The ISP-Reported (BroadMap) and U.S. Census Data

BroadMap, the contractor conducting National Broadband mapping for the U.S. Pacific Territories, has collected data over the past 18 months (as of May 2012) on the number and type of Internet service providers, and on advertised download/upload speeds, by both census block and road segment; on middle-mile providers with backhaul capacity and type, and on whether community anchor institutions receive broadband or provide free public Wi-Fi, including their subscriber download/upload speeds.[75]

The census block and road segment data for Guam was analyzed at the village (Agana Heights, Agat, Asan-Maina, Barrigada. Chalan-Pago-Ordot, Dededo, Hagåtña, Inarajan, Mangilao, Merizo, Mongmong-Toto-Maite, Santa Rita, Sinajana, Talofofo, Tamuning, Umatac, Yigo, and Yona) and territory level. American Samoa data was analyzed at the district (Eastern, Manu'a, and Western)[76] and territory levels, while data reported for the Commonwealth of the Northern Mariana Islands

[75] The community anchor institution survey for Guam did not provide enough observations for meaningful statistical analysis.
[76] BroadMap did not include data for the Swains Island District and Rose Atoll.

(CNMI) was analyzed at the municipality (Rota, Saipan, and Tinian) and territory levels. No greater level of granularity was sought because these levels were similar in scope to the comparable data aggregations provided by NTIA for Hawaii and Puerto Rico on the National Broadband Map. Middle-mile data was not analyzed because it was not available for all three U.S. Pacific Territories and NTIA does not provide comparable data on the National Broadband Map.

Although the study initially set out to assess the broadband available to CNMI's community anchor institutions, only limited analysis of the community anchor data at the territory level was possible because only a very small sample of such institutions provided data on whether they had access to broadband, a smaller sample still provided subscriber download/upload speeds. Moreover, none of the data reported for the U.S. Pacific Territories indicated whether they provided public Wi-Fi access. The implications of this for analysis will be discussed below.

The ISP-reported variables on number of Internet service providers for the district/municipality/village and territory variable collected by BroadMap was computed; the maximum advertised download/upload speeds for each level of granularity was disaggregated into its respective minimum and maximum(for both the census block layer and the road segment layer). Dummy variables were coded 0-1 for type of service: ADSL, Cable, Copper, and SDSL. The natural logarithm of all continuous and quasi-continuous BroadMap variables was calculated to increase normality of the distributions and used for the various tests and models developed in the analysis below.

Census data relating to demographic, social, economic, and housing conditions of the U.S. Pacific Territories, including the following variables were chosen to create a profile down to the district/municipality/village level of each territory and for each territory individually:

total population percent of population male

percent of population 15 years of age and less

percent of population 15-19 years of age

percent of population 20-24 years of age

percent of population 25-34 years of age

percent of population 35-44 years of age

percent of population 45-54 years of age

percent of population 55-59 years of age

percent of population 60-64 years of age

percent of population 65 years of age and older

median age

percent of population ethnically Hawaiian

percent of population ethnically Asian

percent of population ethnically Caucasian

percent of population ethnically black

percent of population ethnically other

percent of family households in total households

percent of households with female heads of household in total households

percent of non-family households in total households

mean household size

mean family size

percent of population enrolled in elementary school

percent of population enrolled in high school

percent of population with less than nine years of education

percent of population with twelve or less years of education without a degree percent of population who are high school graduates

percent of population who have some college

percent of population with associate degree

percent of population with a bachelor degree

percent of population with a graduate degree

percent of population with high school degree or higher

percent of population with a bachelor degree or higher

percent of population in labor force

percent of population in civilian labor

percent of population employed

percent of population unemployed

percent of population not in labor force

percent of population who commute to work in a private vehicle

percent of population in agricultural industry

percent of population in trade industry

percent of population in information industry

percent of population in financial industry

percent of population in professions

percent of population in education

percent of population in public administration

percent of population in private workforce

percent of population in government workforce

median household income

mean household income

per capita income

percent of families at or below the poverty level

percent of families with female head of household at or below the poverty level

percent of households without telephone service

The natural logarithm of all continuous and quasi-continuous census variables was calculated to increase normality of the distributions and used for the various tests and models developed in the analysis below.

<u>Welch's t-test</u>

The t-test is a statistical technique that assesses whether the means of two groups are *statistically* different from each other. The t-tests used in this study are Welch's t-tests. All t-tests test whether the differences between means of two or more groups are statistically significant. Welch's t test is an adaptation of Student's t-test intended for use with two samples having possibly unequal variances.[77] It assumes that both groups of data are sampled from Gaussian populations, but does not assume those two populations have the same variance. As with Student's t-test, it tests whether the means of two samples differ at a given level of statistical significance.

<u>M-Lab Data</u>

The Measurement Lab (M-Lab) is an open, distributed server platform for researchers to deploy Internet measurement tools. It was established by New America Foundation's Open Technology Institute, the PlanetLab Consortium, Google Inc., and academic researchers. M-Lab deploys five network tools collecting data testing Internet performance. One of these, the Network Diagnostic Tool (NDT), collects Web100 variables data that are used to calculate measures of download/upload

[77] B.L. Welch, "The generalization of 'Student's' problem when several different population variances are involved," *Biometrika* 34:1–2 (1947), 28–35.

speeds, latency (delay) and jitter (variation in delay). NDT variables measure **the actual, real-time Internet performance** of testers' Internet connections. The relevant measures for our purposes are download throughput, upload throughput, round trip time, network-limited time ratio, client-limited time ratio, and receiver window scale.

Download throughput is estimated by an NDT test which measures the maximum amount of data that can be transferred from an M-Lab server to the user's device within a defined period of time. It is calculated from Web100 variables using the following formula: download throughput = HCThruOctetsAcked/Duration. The maximum download throughput values collected in the same month by clients geolocated in the same location are grouped together. For each group the median value is calculated.

Upload throughput is estimated by an NDT test which measures the maximum amount of data that can be transferred from a user's device to the M-Lab within a defined period of time. It is calculated from Web100 variables using the following formula: upload throughput = HCThruOctetsReceived/Duration. The maximum upload throughput values collected in the same month by clients geolocated in the same location are grouped together. For each group the median value is calculated.

In testing network and server limitations, NDT attempts to create congestion between a user's machine and the M-Lab server and, as a consequence, individual Round Trip Time (RTT) values measured during the congestion period of an NDT test do not provide a good estimate of the server-client latency. For this reason the RTT of a client during a specific month is estimated as the minimum RTT of all the tests run by that client during that month. It is calculated from Web100 variables using the following formula: RTT = MinRTT.[78] The minimum RTT values collected in the same month by clients geolocated in the same location are grouped together. For each group the median value is calculated.

In testing network and server limitations NDT attempts to create congestion between a user's machine and the M-Lab server and, as a consequence, while running a test can be in three states: network-limited, client-limited, and server-limited. NDT test are never server-limited on the M-Lab platform. Therefore, each test expends some ratio of the test time in a network-limited state or a client-limited state. All server-to-client tests run by the same client in the same month are grouped together and the minimum network-limited and client-limited ratios are calculated from Web100 variables by the following formulae:

• Network-limited time ratio = SndLimTimeCwnd/(SndLimTimeRwin + SndLimTimeCwnd + SndLimTimeSnd); and

• Client-limited time ratio = SndLimTimeRwin/(SndLimTimeRwin + SndLimTimeCwnd + SndLimTimeSnd).

The minimum network-limited time ratio and client-limited time ratio values collected in the same month by clients geolocated in the same location are grouped together. For each group the median value is calculated.

The received window scale is the value negotiated at the beginning of a TCP connection to scale the receiver window size. The receive window size is the maximum amount of received data that can be

[78] The M-Lab metric calculation manual specifies exclusion of the following cases from RTT computation: incomplete tests; tests with CountRTT ≤ 19l; client to server tests. (Tiziana Refice, "Computation of broadband performance metrics using M-Lab data" {http://measurementlab.net/sites/default/files/ComputationofbroadbandperformancemetricsusingMlabdata_0.pdf}, 3).

buffered at one time on the receiving side of a TCP connection. To compute received widow scale values all the server-to-client NDT tests run by the same client during the same month are grouped together. For each group the minimum received window scale is calculated using Web100 variables in the following formula: received widow scale = WinScaleRcvd. With received widow scale the metric is aggregated using means at each level.

These metrics were collected monthly for the U.S. Pacific Territories, Hawaii, Puerto Rico, and the U.S. Virgin Islands from January 1, 2010 through May 2012. They can be seen in the appendix.[79] A correlation matrix was calculated for the M-Lab variables and the natural logarithms of the census variables. Welch's t-tests were run comparing the M-Lab variables over the aggregated U.S. Pacific Territories, the individual territories, Hawaii, Puerto Rico and the U.S. Virgin Islands. Utilizing this matrix and the t-tests of census data reported above, variables were selected for OLS regressions on the M-Lab variables.

Some caution needs to be exercised with the M-Lab data. Google normally does not do calculations of these metrics for cases with fewer than 200 observations per month. If that rule were followed here, there would be no M-Lab data for the U.S. Pacific Territories to examine – even aggregated they do not arise to so many as 200 observations per month and the numbers are smaller still for the individual territories. Similar situations arise for Puerto Rico and the U.S. Virgin Islands, where monthly observations fall short of the recommended number of 200. Smaller *n* observations may prevent convergence on larger values assumed by the law of large numbers, but the M-Lab results for the U.S. Pacific Territories are robustly consistent, which gives greater confidence in them that the smaller *n* in monthly observations is not invalidating for analysis.

A few of M-Lab variables can take natural zero as a value, which precluded the use of

[79] See Appendix 4.

logarithmic transformation to increasingly normalize the distributions.

OLS Regression

Ordinary Least Squares (OLS) regression is a method for estimating the unknown parameters in a linear regression model. The method minimizes the sum of squared vertical distances between the observed responses and the responses predicted by the linear approximation. The OLS estimator is consistent when the regressors are exogenous and there is no multicollinearity, and is optimal when the errors are homoscedastic and serially uncorrelated.

Appendix 2: U.S. Census Variables for CNMI

Total and by District

	CNMI Pct.	Northern Islands Municipality Ptc.	Rota Municipality Ptc.	Saipan Municipality Ptc.	Tinian Municipality Ptc.
TOTPOP	69,221	6	3,283	62,392	3,540
MALE	46.2	33.3	55.2	45.2	54.8
FEMALE	53.8	66.7	44.8	54.8	45.2
POP≤15	22.5	16.1	31.1	21.8	27.1
POP15-19	5.7	33.3	6.7	5.6	5.9
POP20-24	10.9	0	5.1	11.5	5.9
POP25-34	29.2	16.7	20.9	29.7	27.3
POP35-44	18.3	16.7	18.9	18.2	19.8
POP45-54	9.0	16.7	11.2	8.8	9.8
POP55-59	1.7	0	2.1	1.7	1.2
POP60-64	1.2	0	1.3	1.2	1.3
POP≥65	1.5	0	2.7	1.4	1.8
MEDAGE	28.7	25	29.1	28.7	29.2
ETHHAW	31.8	83.3	56.7	30.1	38.2
ETHAS	55.8	16.7	31.9	57.7	44.5
ETHW	1.8	0	1.5	1.8	1.9
ETHBLK	0.1	0	0.1	0.1	0.1
ETHO	0.7	0	0.2	0.7	0.9
FAMH	66.9	100.0	71.1	66.9	63.8

MCH	45.9	0	47.8	45.9	42.7
FH	11.8	100.0	12.5	11.8	10.9
NFH	33.1	0	28.9	33.1	36.2
MNHS	3.66	6.00	3.97	3.64	3.62
MNFS	4.16	5.00	4.39	4.13	4.34
ELEMSCH	58.9	100.0	55.4	59.2	58.4
HSSCH	20.5	0	21.0	20.5	20.0
ED<9	13.8	33.3	12.9	14.1	8.9
ED≤12ND	17.0	0	10.8	17.5	15.3
HSG	35.6	66.7	35.4	35.8	30.9
SCOLL	12.6	0	18.0	12.0	18.1
ASD	5.6	0	7.2	5.5	6.0
BD	12.7	0	13.4	12.3	18.1
GRADD	2.8	0	2.3	2.8	2.7
PCT≥HSG	69.2	66.7	76.3	68.5	75.8
PCT≥BD	15.5	0	15.7	15.2	20.8
INLF	84.1	20.0	78.6	84.4	82.6
CIVLAB	84.1	20.0	78.6	84.4	82.6
EMPL	80.8	20.0	72.0	81.5	76.2
UNEMPL	3.2	0	6.6	2.9	6.3
NILF	15.9	80.0	21.4	15.6	17.4
COMMVEH	55.3	0	70.7	55.1	49.8
COMMPT	0.6	0	0.4	0.6	0.3
COMMMTC	0.1	0	0.2	0.0	0.4
COMMBIC	0.5	0	2.0	0.4	1.0
COMMW	37.2	0	19.2	37.6	42.5

COMMO	1.9	0	1.2	1.9	0.9
INDAGR	1.5	0	7.2	1.1	3.3
INDTRA	3.4	0	4.2	3.3	5.2
INDINF	1.4	0	0.3	1.4	2.0
INDFIN	2.4	0	2.1	2.4	2.0
INDPROF	5.0	100	1.1	5.3	1.9
INDED	5.2	0	12.4	4.8	8.3
INDOS	5.6	0	10.1	5.4	5.0
INDPA	6.0	0	21.0	5.0	14.9
PRIVWKR	87.2	100.0	62.9	88.8	73.2
GOVWKR	11.7	0	35.7	10.0	26.0
MEDHI	22,898	26,250	28,708	22,555	23,542
MNHI	37,015	26,000	42,524	36,718	36,454
PCINC	9,151	4,333	10,326	9,021	10,344
MEDEARNM	9,927	11,250	11,833	9,828	10,556
MEDEARNF	10,113	0	13,516	10,074	10,556
POVFAM	30.6	100.0	23.0	31.2	28.0
POVFF	49.2	100.0	53.7	49.0	48.8
POVI	46.0	83.3	34.2	46.9	41.2
WOTEL	29.9	0	37.5	28.8	40.0

<u>Table 1</u>

Mean and Median Values of Number of Wireline Internet Service Providers, U.S. Pacific Territories

	Number of Internet Service Providers per District/Village	
	Mean	Median
American Samoa	1.9429	2.0000
Commonwealth of the Northern Marianas Islands	1.8313	2.0000
Guam	3.0000	3.0000

Source: BroadMap

Table 2

Median Advertised Speed, Download/Upload by Carrier Type, Census District and Road Segment Layers, U.S. Pacific Territories

		Maximum Advertised Speed DOWN (Mbps)		Maximum Advertised Speed UP (Mbps)	
	Type	Census District Layer	Road Segment Layer	Census District Layer	Road Segment Layer
American Samoa	All	$0.768 \leq s < 1.5$	$0.768 \leq s < 1.5$	$0.200 \leq s < 0.768$	$0.200 \leq s < 0.768$
	ADSL	$0.768 \leq s < 1.5$	$0.768 \leq s < 1.5$	$0.200 \leq s < 0.768$	$0.200 \leq s < 0.768$
	Cable	$1.5 \leq s < 3$	-	$0.200 \leq s < 0.768$	-
Commonwealth of the Northern Marianas Islands	All	$1.5 \leq s < 3$	$1.5 \leq s < 3$	$0.768 \leq s < 1.5$	$0.768 \leq s < 1.5$
	ADSL	$1.5 \leq s < 3$	$1.5 \leq s < 3$	$0.768 \leq s < 1.5$	$0.768 \leq s < 1.5$
	Cable	$1.5 \leq s < 3$	-	$0.200 \leq s < 0.768$	-
Guam	All	$6 \leq s < 10$	$6 \leq s < 10$	$1.5 \leq s < 3$	$1.5 \leq s < 3$
	ADSL	$6 \leq s < 10$	$6 \leq s < 10$	$1.5 \leq s < 3$	$1.5 \leq s < 3$
	Cable	$10 \leq s < 25$	$10 \leq s < 25$	$1.5 \leq s < 3$	$1.5 \leq s < 3$
	Copper	$1.5 \leq s < 3$	$1.5 \leq s < 3$	$1.5 \leq s < 3$	$1.5 \leq s < 3$
	SDSL	$6 \leq s < 10$	$1.5 \leq s < 3$	$1.5 \leq s < 3$	$1.5 \leq s < 3$

Source: BroadMap

Table 3 Wireless Broadband Providers and Maximum Advertised Download and Upload Speeds Per ISP Per Territory			
Wireless Providers	Location	Maximum Advertised Download Speed (Mbps)	Maximum Advertised Upload Speed (Mbps)
AST Telecom, LLC	American Samoa	$3 \leq s < 6$	$0.768 \leq s < 3$
PTI Pacifica Inc.	CNMI	$3 \leq s < 6$	$0.768 \leq s < 3$
DoCoMo Pacific	Guam	$1.4 \leq s < 3$	$0.768 \leq s < 3$
PTI Pacifica Inc.	Guam	$1.4 \leq s < 3$	$0.768 \leq s < 3$

Source: BroadMap

Appendix 3: ISP and Census Variable Regression Results

<u>Table 4</u>
Two-Sample Welch's t-Tests of BroadMap Variables:
Means for Commonwealth of the Northern Marianas Islands – (minus) Means for American Samoa

BroadMap Variable	Combined Obs.	μ(CNMI) - μ(AS)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Number if non-Wireless ISPs	2721	-0.0773513	2171.92	2171.92	0.0000	0.0000	1.0000
Minimum of the maximum advertised download Speed Range	2721	0.5035213	752	44.6857	1.0000	0.0000	1.0000
Maximum of the Maximum Advertised Download Speed Range	2721	0.7411037	1967	49.1123	1.0000	0.0000	1.0000
Minimum of the Maximum Advertised Upload Speed Range	2721	0.3687311	1967	49.1123	1.0000	0.0000	1.0000
Maximum of the Maximum Advertised Upload Speed Range	2721	0.72408	752	44.6857	1.0000	0.0000	1.0000

Table 5

Two-Sample Welch's t-Tests of BroadMap Variables:

Means for Commonwealth of the Northern Marianas Islands - (minus) Means for Guam

BroadMap Variable	Combined Obs.	μ(CNMI) - μ(Guam)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Number of ISPs	16618	-0.5223985	1967	-89.2572	0.0000	0.0000	1.0000
Minimum of the maximum advertised download Speed Range	16618	-1.18377	14649	-0.15	0.0000	0.0000	1.0000
Maximum of the Maximum Advertised Download Speed Range	16618	-1.283461	2358.72	-81.2536	0.0000	0.0000	1.0000
Minimum of the Maximum Advertised Upload Speed Range	16618	-0.9980826	3808.68	-0.11	0.0000	0.0000	1.0000
Maximum of the Maximum Advertised Upload Speed Range	16618	-0.610953	14649	-0.12	0.0000	0.0000	1.0000

Table 6

OLS Regression of Census Variables on Number of Wireline ISPs:

Commonwealth of the Northern Mariana and American Samoa Dataset

Number of obs = 2721	R-squared = 0.9999
F(4, 2716) = 5901.50	Adj R-squared = 0.9999
Prob > F = 0.0000	Root MSE = 0 .00274

Number of ISPs	Coef.	Std. Err.	T	P>|t|
Total Population	0.2975769	0.000137	2172.31	0.0000
Percent in Agricultural Industry	-0.1651023	0.0002643	-624.57	0.0000
Median Household Income	0.5717843	0.0004486	1274.55	0.0000
Percent of Homes Without Telephone Service	-0.0265759	0.0004899	-54.25	0.0000
Constant	3.034256	0.0044736	678.25	0.0000

Table 7

OLS Regression of Census Variables on Number of Wireline ISPs:

Commonwealth of the Northern Mariana and Guam Dataset

Number of obs = 16618	R-squared = 0.9300
F(7, 16610) = 31505.05	Adj R-squared = 0.9299
Prob > F = 0.0000	Root MSE = 0 .05055

Number of ISPs	Coef.	Std. Err.	T	P>|t|
CNMI	-0.031119	0.0036086	-8.62	0.0000
Total Population	0.0106689	0.0005832	18.29	0.0000
Percent of Workforce Employed	0.0920533	0.0024671	37.31	0.0000
Percent in Agricultural Industry	-0.1201706	0.0012032	-99.87	0.0000
Per Capita Income	0.4402581	0.0047864	91.98	0.0000
Percent of Families at or below Poverty Level	-0.4964163	0.0032987	-150.49	0.0000
Percent of Homes Without Telephone Service	-0.4717951	0.0031378	-150.36	0.0000
Constant	4.298089	0.0445513	96.48	0.0000

Table 8

Two-Sample Welch's t-Tests of BroadMap Variables:

Means for Commonwealth of the Northern Marianas Islands – (minus) Means for Hawaii

BroadMap Variable	Combined Obs.	μ(CNMI) - μ(Hawaii)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Number of ISPs	2785	-1.189506	1447.44	-0.11	0.0000	0.0000	1.0000
Minimum of the Maximum Advertised Download Speed Range	2785	-0.0859474	816	-2.555	0.0054	0.0108	0.9946
Max. of the Max. Advertised Download Range	2785	-2.831141	1093.66	-70.4523	0.0000	0.0000	1.0000
Minimum of the Maximum Advertised Upload Speed Range	2785	0.3621958	874.232	8.9122	1.0000	0.0000	0.0000
Maximum of the Maximum Advertised Upload Speed Range	2785	-0.599948	816	-20.4212	0	0	1

Table 9

OLS Regression of Census Variables on Number of Wireline ISPs:

Commonwealth of the Northern Mariana and Hawaii Dataset

Number of obs = 2784	R-squared = 0.9930
F(5, 2778) = 5170.09	Adj R-squared = 0.9939
Prob > F = 0.0000	Root MSE = 0 .01563

Number of ISPs	Coef.	Std. Err.	T	P>|t|
Total Population	0.3625546	0.0016678	217.38	0.0000
Percent in Agricultural Industry	-0.1473216	0.0021106	-69.8	0.0000
Per Capita Income	1.035182	0.0092038	112.47	0.0000
Percent of Families at/below Poverty	-0.3142976	0.0044125	-71.23	0.0000
Percent of Homes Without Telephone Service	-0.1864743	0.0045935	-40.6	0.0000
Constant	14.45828	0.1166578	123.94	0.0000

Table 10

Two-Sample Welch's t-Tests of BroadMap Variables:

Means for Commonwealth of the Northern Marianas Islands – (minus) Means for Puerto Rico

BroadMap Variable	Combined Obs.	μ(CNMI) - μ(PR)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Number of ISPs	2249	-0.7353333	382.031	-47.9499	0.0000	0.0000	1.0000
Minimum of the Maximum Advertised Download Speed Range	2249	0.3100732	280	6.172	1.0000	0.0000	0.0000
Maximum of the Maximum Advertised Download Speed Range	2249	-3.103966	280	-58.2383	0.0000	0.0000	1.0000
Minimum of the Maximum Advertised Upload Speed Range	2249	0.5270338	296.711	11.8773	1.0000	0.0000	0.0000
Maximum of the Maximum Advertised Upload Speed Range	2249	-0.3195388	280	-10.8341	0.0000	0.0000	1.0000

Table 11

OLS Regression of Census Variables on Number of Wireline ISPs:

Commonwealth of the Northern Mariana and Puerto Rico Dataset

Number of obs = 2242	R-squared = 0.9209
F(5, 2236) = 5207.42	Adj R-squared= 0.9207
Prob > F = 0.0000	Root MSE = 0 .0618

Number of ISPs	Coef.	Std. Err.	T	P>|t|
CNMI	-0.4484141	0.0353548	-12.68	0.0000
Percent of Workforce Employed	0.1673788	0.0432393	3.87	
Percent in Agricultural Industry	-0.0292076	0.0036295	-8.05	0.0000
Per Capita Income	0.5169145	0.0161223	32.06	0.0000
Percent of Homes Without Telephone Service	-0.1648036	0.0122458	-13.46	0.0000
Constant	2.271926	0.1439758	15.78	0.0000

Table 12

Two-Sample Welch's t-Tests of BroadMap Variables:

Means for Commonwealth of the Northern Marianas Islands – (minus) Means for U.S. Virgin Islands

BroadMap Variable	Combined Obs.	μ(CNMI) - μ(USVI)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Number of ISPs	2088	-0.5223985	1967	-89.2572	0.0000	0.0000	1.0000
Minimum of the Maximum Advertised Download Speed Range	2088	0.8007662	119	18.7145	1.0000	0.0000	0.0000
Maximum of the Maximum Advertised Download Speed Range	2088	-1.851422	148.994	-40.0757	0.0000	0.0000	1.0000
Minimum of the Maximum Advertised Upload Speed Range	2088	0.5940784	121.284	7.6979	1.0000	0.0000	0.0000
Maximum of the Maximum Advertised Upload Speed Range	2088	-0.3193228	119	-6.2618	0.0000	0.0000	1.0000

Table 13

OLS Regression of Census Variables on Number of Wireline ISPs:

Commonwealth of the Northern Mariana and U.S. Virgin Islands Dataset

Number of obs = 2088	R-squared = 0.8881
F(2, 2085) = 8270.49	Adj R-squared = 0.8880
Prob > F = 0.0000	Root MSE = 0 .09368

Number of ISPs	Coef.	Std. Err.	T	P>|t|
Total Population	0.096472	0.001434	-67.27	0.0000
Percent in Agricultural Industry	-0.582444	0.0045854	- 127.02	0.0000
Constant	1.805782	0.0158853	113.68	0.0000

Table 14

Analysis of Covariance: Number of Wireline ISPs

U.S. Pacific Territories, Hawaii, Puerto Rico and U.S. Virgin Island Dataset

Number of obs. = 18589	R-squared = 0.8178
F(5, 18583) =16685.31	Adj. R-squared = 0.8178
Prob > F = 0.0000	Root MSE = 0.1112

Number of ISPs	Coef.	Std. Err.	t	P>|t|
American Samoa	-1.112155	0.0056175	-197.98	0.0000
Commonwealth of Northern Marianas Islands	-1.189506	0.004628	-257.02	0.0000
Guam	-0.667108	0.0039974	-166.89	0.0000
Puerto Rico	-0.4541732	0.0076903	-59.06	0.0000
U.S. Virgin Islands	-0.667108	0.0108711	-61.37	0.0000
Constant	1.76572	0.0038904	453.87	0.0000

Table 15

OLS Regression of Census Variables on Number of Wireline ISPs:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 18144	R-squared = 0.9535
F(11,18132) = 33742.60	Adj R-squared = 0.9534
Prob > F = 0.0000	Root MSE = 0.05501

Number of ISPs	Coef.	Std. Err.	t	P>|t|
Distance	-0.000039	0.000125	-31.23	0.0000
Total Population	0.1292844	0.0010622	121.71	0.0000
Percent Ethnically Hawaiian	-0.1477702	0.0020391	-72.47	0.0000
Percent Ethnically Caucasian	0.1953585	0.0014482	134.9	0.0000
Percent with High School Degree or Higher	2.503465	0.0242733	103.14	0.0000
Percent with Bachelor Degree or Higher	0.4387525	0.0041944	104.6	0.0000
Percent of Workforce Employed	0.455117	0.0047729	95.35	0.0000
Percent in Agricultural Industry	-0.0765598	0.0010708	71.5	0.0000
Per Capital Income	0.9656339	0.0053552	180.32	0.0000
Percent of Families At or Below the Poverty Level	-0.2040469	0.0023497	86.84	0.0000
Percent of Homes Without Telephone Service	-0.1415764	0.0020505	69.04	0.0000
Constant	3.595941	0.1111263	32.36	0.0000

Appendix 4: M-Lab Data

Table 16

Comparison of M-Lab Metrics

	Albania	Belarus	Bosnia-Herzegovina	U.S.	Netherlands	Belgium
Download Throughput (Mbps)	0.58	0.68	1.13	4.91	7.42	5.23
Upload Throughput (Mbps)	0.23	0.31	0.15	0.78	0.75	0.67
Round Trip Time	127	125	83	35	21	33
Network-Limited Time Ratio	0.96	0.88	0.91	0.67	0.3	0.4
Client-Limited Time Ratio	0.14	0.11	0.08	0.32	0.7	0.59
Weighted Receiver Scale	1.16	1.03	1.25	2.67	2.64	2.72

	American Samoa	Commonwealth of the Northern Marianas Islands	Guam	Puerto Rico	U.S. Virgin Islands	Hawaii
Download Throughput (Mbps)	0.52	0.31	0.75	1.38	0.61	3.46
Upload Throughput (Mbps)	0.38	0.21	0.33	0.34	0.46	0.72
Round Trip Time	219.07	327.68	271.46	78.19	101.25	78..89
Network-Limited Time Ratio	0.23	0.33	0.84	0.36	0.04	0.86
Client-Limited Time Ratio	0.23	0.4	0.1	0.37	0.04	0.12
Weighted Receiver Scale	1.25	1.62	2.29	1.88	1.79	2.73

Note: Table 16 presents average actual measurement values for the months from January 1, 2010 to April 30, 2012, in the case of the nations, and updated through August 2012 for CNMI and the other U.S. territories with respect to download and upload throughput (the other M-Lab metrics are through April 2012 for all locations).

U.S. Territories, Hawaii and Mississippi

(Monthly aggregation from Jan. 2010 through April 2012)

American Samoa

	Download Throughput (Mbps)	Upload Throughput (Mbps)	Network-Limited Time Ratio	Client-Limited Time Ratio	Round Trip Time	Weighted Receiver Window
1/1/10	.	.	.	.	.	.
2/1/10	0.38	0.13	0.49	0.49	168	0.4
3/1/10	0.46	0.17	0.08	0.08	149	1.63
4/1/10	2.23	1.01	0.28	0.28	125	-0.33
5/1/10	0.39	0.44	0	0	164	0.25
6/1/10	0.11	0.16	0.11	0.11	184	1.1
7/1/10	0.65	0.09	0.59	0.59	212	0
8/1/10	0.14	0.13	0.11	0.11	198	1.67
9/1/10	0.75	0.76	0.13	0.13	125	2
10/1/10	0.26	0.40	0.53	0.53	269	0.5
11/1/10	3.13	1.13	0.47	0.47	290	0.2
12/1/10	1.02	0.51	0.1	0.1	216	-0.5
1/1/11	0.14	0.36	0.39	0.39	138	0.2
2/1/11	0.94	0.42	0	0.39	162	-1
3/1/11	0.15	0.36	0.02	0	196	2.25
4/1/11	0.32	0.17	0.28	0.02	199	-0.33

5/1/11	0.32	0.18	0.59	0.59	277	0
6/1/11	0.26	0.80	0.29	0.29	267	1.33
7/1/11	0.23	0.75	0	0	266	-0.4
8/1/11	0.07	0.28	0	0	152	2
9/1/11	0.13	0.08	0.25	0	280	-0.57
10/1/11	.	0.48	0.33	0.25	378	5
11/1/11	0.14	0.18	0	0	245	2.2
12/1/11	0.22	0.55	0.4	0.4	250	3
1/1/12	0.07	0.19	0.29	0.25	245	4.3
2/1/12	1.04	0.21	0.29	0.29	260	2.8
3/1/12	0.46	0.20	0.25	0.02	250	2
4/1/12	0.21	0.06	0	0.4	250	4
5/1/12	.	0.44	-	-	-	-
6/1/12	0.37	0.56	-	-	-	-
7/1/12	0.19	0.21	-	-	-	-
8/1/12	0.17	0.45	-	-	-	-
Mean	0.52	0.38	0.23	0.23	219.07	1.25

Commonwealth of the Mariana Islands

	Download Throughput (Mbps)	Upload Throughput (Mbps)	Network-Limited Time Ratio	Client-Limited Time Ratio	Round Trip Time	Weighted Receiver Window
1/1/10	.	0.26	0.76	0.23	249	1.05
2/1/10	0.52	0.29	0.54	0.33	240	1.83
3/1/10	0.43	0.25	0.63	0.33	251	1.83
4/1/10	0.48	0.20	0.48	0.41	241	1.83
5/1/10	0.44	0.20	0.23	0.66	251	1.83
6/1/10	0.43	0.29	0.25	0.73	354	1.84
7/1/10	0.41	0.22	0.29	0.67	368	1.44
8/1/10	0.23	0.16	0.27	0.71	361	1.84
9/1/10	0.29	0.16	0.2	0.78	353	1.84
10/1/10	0.23	0.17	0.24	0.71	368	1.85
11/1/10	0.36	0.21	0.27	0.69	342	1.85
12/1/10	0.43	0.22	0.45	0.49	342	1.43
1/1/11	0.26	0.17	0.23	0.23	363	1.85
2/1/11	0.45	0.31	0.3	0.3	372	1.85
3/1/11	0.20	0.16	0.2	0.2	353	1.85
4/1/11	0.23	0.17	0.27	0.27	334	1.85
5/1/11	0.34	0.32	0.23	0.23	324	1.96
6/1/11	0.25	0.22	0.28	0.28	345	1.96

7/1/11	0.15	0.24	0.29	0.31	337	1.31
8/1/11	0.24	0.21	0.23	0.23	329	1.27
9/1/11	0.23	0.16	0.22	0.22	332	1.97
10/1/11	0.26	0.20	0.39	0.39	340	1.05
11/1/11	0.29	0.17	0.34	0.34	333	1.38
12/1/11	0.28	0.21	0.18	0.18	336	1.26
1/1/12	0.28	0.13	0.25	0.37	350	1.54
2/1/12	0.46	0.31	0.27	0.33	347	1.32
3/1/12	0.53	0.25	0.23	0.2	332	1.25
4/1/12	0.24	0.29	0.38	0.31	328	1.27
5/1/12	0.26	0.17	-	-	-	-
6/1/12	0.15	0.17	-	-	-	-
7/1/12	0.08	0.14	-	-	-	-
8/1/12	0.13	0.25	-	-	-	-
Mean	0.31	0.21	0.32	0.4	327.68	1.62

Guam

	Download Throughput (Mbps)	Upload Throughput (Mbps)	Network-Limited Time Ratio	Client-Limited Time Ratio	Round Trip Time	Weighted Receiver Window
1/1/10	0.76	0.27	0.89	0.08	201	0.86
2/1/10	0.88	0.31	0.84	0.11	176	2.15
3/1/10	0.94	0.32	0.8	0.13	174	1.95
4/1/10	0.81	0.31	0.68	0.21	179	1.66
5/1/10	1.19	0.34	0.79	0.13	175	2.02
6/1/10	0.81	0.33	0.78	0.17	287	1.7
7/1/10	0.72	0.32	0.83	0.11	296	1.74
8/1/10	0.70	0.31	0.8	0.12	306	1.99
9/1/10	0.65	0.30	0.81	0.13	333	1.83
10/1/10	0.62	0.30	0.84	0.1	307	1.59
11/1/10	0.69	0.31	0.83	0.11	294	1.8
12/1/10	0.66	0.32	0.82	0.13	288	2.05
1/1/11	0.65	0.31	0.86	0.1	305	2.14
2/1/11	0.66	0.31	0.81	0.13	288	2.01
3/1/11	0.60	0.32	0.82	0.11	291	2.27
4/1/11	0.64	0.32	0.86	0.08	289	2.07
5/1/11	0.60	0.33	0.85	0.1	290	2
6/1/11	0.60	0.32	0.85	0.1	287	2.29

7/1/11	0.76	0.33	0.86	0.1	288	2.15
8/1/11	0.69	0.33	0.85	0.09	291	2.48
9/1/11	0.67	0.33	0.88	0.08	289	2.29
10/1/11	0.63	0.35	0.86	0.08	294	2.34
11/1/11	0.80	0.33	0.9	0.06	276	2.38
12/1/11	0.77	0.36	0.89	0.06	257	2.79
1/1/12	0.79	0.35	0.84	0.08	280	2.35
2/1/12	0.71	0.34	0.87	0.09	287	2.41
3/1/12	0.69	0.38	0.83	0.06	291	2.33
4/1/12	0.64	0.34	0.88	0.06	282	2.29
5/1/12	0.88	0.34	-	-	-	-
6/1/12	0.85	0.37	-	-	-	-
7/1/12	0.86	0.34	-	-	-	-
8/1/12	1.23	0.35	-	-	-	-
Mean	0.75	0.33	0.84	0.1	271.46	2.07

Puerto Rico

	Download Throughput (Mbps)	Upload Throughput (Mbps)	Network-Limited Time Ratio	Client-Limited Time Ratio	Round Trip Time	Weighted Receiver Window
1/1/10	1.06	0.32	0.34	0.4	82.5	1.76
2/1/10	1.08	0.32	0.4	0.37	74.5	2.4
3/1/10	1.06	0.32	0.39	0.38	75	1.75
4/1/10	1.00	0.31	0.35	0.37	81	1.76
5/1/10	1.04	0.33	0.36	0.37	78	1.77
6/1/10	1.07	0.34	0.39	0.37	76	1.77
7/1/10	1.05	0.34	0.39	0.37	81	1.77
8/1/10	1.11	0.33	0.4	0.37	79	1.78
9/1/10	1.18	0.32	0.35	0.37	77	1.78
10/1/10	1.34	0.33	0.35	0.38	75	1.78
11/1/10	1.38	0.33	0.35	0.38	82	1.78
12/1/10	1.40	0.33	0.35	0.38	77	1.78
1/1/11	1.30	0.33	0.35	0.38	76	2.39
2/1/11	1.44	0.33	0.35	0.38	78	1.79
3/1/11	1.32	0.34	0.35	0.38	81	1.79
4/1/11	1.24	0.33	0.35	0.38	79	1.79
5/1/11	1.39	0.34	0.35	0.38	82.5	1.79
6/1/11	1.05	0.33	0.35	0.38	75	1.79

7/1/11	1.32	0.34	0.35	0.38	76.7	1.81
8/1/11	1.31	0.34	0.35	0.38	79	2.4
9/1/11	1.53	0.34	0.35	0.38	81	1.81
10/1/11	1.69	0.35	0.35	0.38	74	1.81
11/1/11	1.58	0.34	0.37	0.38	76	1.82
12/1/11	1.81	0.34	0.37	0.38	79	2.41
1/1/12	1.63	0.35	0.4	0.34	80	1.99
2/1/12	1.68	0.35	0.36	0.33	81	1.89
3/1/12	1.80	0.35	0.36	0.35	77	1.77
4/1/12	1.62	0.34	0.3	0.36	76	1.81
5/1/12	1.61	0.34	-	-	-	-
6/1/12	1.72	0.35	-	-	-	-
7/1/12	1.70	0.34	-	-	-	-
8/1/12	1.70	0.34	-	-	-	-
Mean	1.38	0.34	0.36	0.37	78.19	1.88

U.S. Virgin Islands

	Download Throughput (Mbps)	Upload Throughput (Mbps)	Network-Limited Time Ratio	Client-Limited Time Ratio	Round Trip Time	Weighted Receiver Window
1/1/10	1.15	0.53	0.18	0.18	84	3.13
2/1/10	0.47	0.41	0.06	0.06	93	1.09
3/1/10	0.50	0.44	0.06	0.06	111	1.34
4/1/10	0.42	0.43	0.05	0.05	110	1.49
5/1/10	0.44	0.41	0.03	0.03	109	0.47
6/1/10	0.55	0.45	0.03	0.03	113	1.2
7/1/10	0.52	0.44	0.17	0.17	86	1.63
8/1/10	0.45	0.43	0.03	0.03	84	1.57
9/1/10	0.55	0.44	0.04	0.04	86	1.42
10/1/10	0.55	0.45	0.02	0.02	93	1.76
11/1/10	0.73	0.45	0.04	0.04	109	1.9
12/1/10	0.61	0.45	0.03	0.03	110	1.57
1/1/11	0.48	0.43	0	0	111	1.6
2/1/11	0.65	0.44	0	0	113	1.39
3/1/11	0.50	0.43	0.02	0.02	110	1.42
4/1/11	0.59	0.46	0.02	0.02	97	1.71
5/1/11	0.65	0.45	0.04	0.03	94	2.11
6/1/11	0.69	0.47	0.04	0.04	101	1.86

7/1/11	0.55	0.45	0.06	0.05	107	2.06
8/1/11	0.73	0.46	0.02	0.02	112	1.88
9/1/11	0.54	0.48	0	0	99	1.71
10/1/11	0.64	0.45	0.02	0.02	89	2.6
11/1/11	0.53	0.45	0.01	0.01	100	2.66
12/1/11	0.52	0.46	0.01	0.01	111	2.15
1/1/12	0.85	0.54	0.03	0.02	88	2.27
2/1/12	0.76	0.48	0.01	0.02	101	2.34
3/1/12	0.72	0.60	0	0.01	105	1.89
4/1/12	0.73	0.65	0.02	0.04	109	1.95
5/1/12	0.60	0.46	-	-	-	-
6/1/12	0.65	0.46	-	-	-	-
7/1/12	0.53	0.46	-	-	-	-
8/1/12	0.56	0.46	-	-	-	-
Mean	0.61	0.46	0.04	0.04	101.25	1.79

Hawaii

	Download Throughput (Mbps)	Upload Throughput (Mbps)	Network-Limited Time Ratio	Client-Limited Time Ratio	Round Trip Time	Weighted Receiver Window
1/1/10	.	0.61	0.83	0.16	76	2.25
2/1/10	3.22	0.72	0.92	0.06	73	2.98
3/1/10	4.23	0.72	0.84	0.15	73	2.96
4/1/10	3.62	0.68	0.85	0.14	78	2.82
5/1/10	3.87	0.72	0.85	0.14	75	2.96
6/1/10	4.01	0.71	0.84	0.15	74	2.93
7/1/10	3.53	0.72	0.81	0.17	74	2.82
8/1/10	3	0.72	0.9	0.08	77	2.17
9/1/10	3.12	0.73	0.91	0.08	76	2.33
10/1/10	2.82	0.72	0.92	0.07	77	2.37
11/1/10	3.22	0.72	0.9	0.08	77	2.45
12/1/10	2.8	0.72	0.89	0.09	77	2.53
1/1/11	2.66	0.72	0.91	0.08	79	2.54
2/1/11	3.15	0.72	0.85	0.14	82	2.6
3/1/11	3.22	0.72	0.85	0.14	80	2.58
4/1/11	3.2	0.72	0.89	0.09	80	2.77
5/1/11	3.18	0.72	0.88	0.1	80	2.62
6/1/11	3.48	0.73	0.87	0.11	85	2.83

7/1/11	3.18	0.72	0.86	0.12	89	2.71
8/1/11	3.64	0.73	0.89	0.09	79	2.9
9/1/11	3.59	0.75	0.87	0.11	78	2.82
10/1/11	3.91	0.74	0.85	0.13	76	2.87
11/1/11	3.68	0.72	0.83	0.16	78	2.91
12/1/11	4.07	0.75	0.77	0.22	77	3.02
1/1/12	3.96	0.73	0.88	0.1	84	3
2/1/12	3.9	0.73	0.84	0.15	77	2.84
3/1/12	3.32	0.72	0.85	0.12	92	2.89
4/1/12	3.84	0.74	0.82	0.16	86	2.92
Mean	3.46	0.72	0.86	0.12	78.89	2.73

Mississippi

	Download Throughput (Mbps)	Upload Throughput (Mbps)	Network-Limited Time Ratio	Client-Limited Time Ratio	Round Trip Time	Weighted Receiver Window
1/1/10	3.17	0.37	0.92	0.07	48	1.73
2/1/10	3.26	0.34	0.88	0.11	37	2.72
3/1/10	3.55	0.36	0.88	0.11	37	2.42
4/1/10	3.16	0.36	0.85	0.14	36	2.35
5/1/10	3.49	0.36	0.86	0.13	39	2.56
6/1/10	3.48	0.36	0.88	0.1	39	2.56
7/1/10	3.51	0.36	0.87	0.12	40	2.57
8/1/10	2.71	0.36	0.92	0.07	48	2.9
9/1/10	2.8	0.36	0.92	0.07	46	2.9
10/1/10	2.77	0.36	0.93	0.06	48	2.4
11/1/10	2.81	0.36	0.92	0.07	50	2.37
12/1/10	2.69	0.36	0.93	0.06	52	2.48
1/1/11	2.48	0.36	0.92	0.07	53	2.47
2/1/11	2.44	0.36	0.93	0.06	56	2.66
3/1/11	2.76	0.36	0.93	0.05	50	2.72
4/1/11	2.87	0.38	0.94	0.05	49	2.62
5/1/11	3.16	0.37	0.92	0.06	48	2.58
6/1/11	2.95	0.35	0.93	0.05	49	2.86
7/1/11	3.54	0.36	0.93	0.05	49	2.76

8/1/11	3.74	0.36	0.91	0.06	48	2.84
9/1/11	4.15	0.41	0.93	0.06	47	2.98
10/1/11	4.08	0.4	0.91	0.07	53	2.79
11/1/11	4.11	0.41	0.91	0.07	51	2.98
12/1/11	4.52	0.45	0.92	0.07	51	3.12
1/1/12	4.52	0.46	0.91	0.07	50	3.17
2/1/12	4.28	0.46	0.89	0.09	51	3.02
3/1/12	4.83	0.45	0.91	0.07	47	3.18
4/1/12	5.27	0.52	0.9	0.08	46	3.03

Appendix 5: M-Lab Variable Regression Results

<u>Table 17</u>

Two-Sample Welch's t-Tests of Download Throughput:

Means for Commonwealth of the Northern Marianas Islands – (minus) Means for Guam, American Samoa, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(CNMI) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Guam	63	-.4463004	58.8172	12.9833	0.0000	0.0000	1.0000
American Samoa	60	-.2071301	29.6894	-1.6395	0.0558	0.1117	0.9442
Puerto Rico	63	-1.073175	43.8254	-20.9938	0.0000	0.0000	1.0000
U.S. Virgin Islands	63	-.2981754	59.7527	-8.9344	00000	0.0000	1.0000
Hawaii	58	-3.151613	29.6467	-37.3135	0.0000	0.0000	1.0000

Table 18

Two-Sample Welch's t-Tests of Upload Throughput:

Means for Commonwealth of the Northern Marianas Islands - (minus) Means for Guam, American Samoa, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(CNMI) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Guam	64	-.1128125	40.9993	-10.9576	0.0000	0.0000	1.0000
American Samoa	63	-.1675806	32.2292	-3.3274	0.0011	0.0022	0.9989
Puerto Rico	55	-.1203125	33.1947	-12.3994	0.0000	0.0000	1.000
U.S. Virgin Islands	64	-.2496875	61.6866	-19.1640	0.0000	0.0000	1.0000
Hawaii	60	-.5046429	44.9915	-47.4147	0.0000	0.0000	1.0000

Table 19

Two-Sample Welch's t-Tests of Network-Limited Time Ratio:

Means for Commonwealth of Northern Marianas Islands - (minus) Means for Guam, American Samoa, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(CNMI) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Guam	56	-.5185714	32.3683	-18.8805	0.0000	0.0000	1.0000
American Samoa	55	.0856349	46.7097	1.8674	0.9659	0.0681	0.0341
Puerto Rico	56	-.0421429	28.3744	-1.5894	0.0615	0.1230	0.9385
U.S. Virgin Islands	56	2807143	32.1181	10.2426	1.0000	0.0000	0.0000
Hawaii	56	-.5453571	30.5902	-20.1663	0.0000	0.0000	1.0000

Table 20

Two-Sample Welch's t-Tests of Client-Limited Time Ratio:

Means for the Commonwealth of the Marianas Islands - (minus) Means for Guam, American Samoa, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(AS) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Guam	56	.2935714	28.5939	7.8335	1.0000	0.0000	0.0000
American Samoa	55	.1686111	52.6808	3.1314	0.9986	0.0028	0.0014
Puerto Rico	56	.0242857	27.2728	0.6559	0.7413	0.5174	0.2587
U.S. Virgin Islands	56	.36	29.5143	9.5271	1.0000	0.0000	0.0000
Hawaii	56	.2764286	28.9801	7.3505	1.0000	0.0000	0.0000

Table 21

Two-Sample Welch's t-Tests of Round Trip Time:

Means for the Commonwealth of the Northern Marianas Islands - (minus) Means for Guam, American Samoa, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(CNMI) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Guam	56	56.21429	53.4812	4.9077	1.0000	0.0000	0.0000
American Samoa	55	108.6045	45.2812	7.7741	1.0000	0.0000	0.0000
Puerto Rico	56	249.4929	27.2228	32.3759	1.0000	0.0000	0.0000
U.S. Virgin Islands	56	226.4286	30.2889	28.5828	1.0000	0.0000	0.0000
Hawaii	56	248.7857	27.7036	32.1419	1.0000	0.0000	0.0000

Table 22

Two-Sample Welch's t-Tests of Weighted Receiver Window Scale:

Means for the Commonwealth of the Northern Marianas Islands - (minus) Means for Guam, American Samoa, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(CNMI) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
Guam	56	-.4475	52.223	-4.9968	0.0000	0.0000	1.0000
American Samoa	56	.3732804	27.7784	1.1872	0.8774	0.2452	0.1226
Puerto Rico	56	-.2621428	49.257	-3.7102	0.0003	0.0005	0.9997
U.S. Virgin Islands	56	-.1703571	42.9103	-1.4769	0.0522	0.1470	0.9265
Hawaii	56	-1.106786	51.6035	-15.0874	0.0000	0.0000	1.0000

Table 23

OLS Regression of Census Variables on Download Throughput:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135 R-squared = 0.9772

F(8,129) = 5214.60 Adj R-squared = 0.9763

Prob > F = 0.0000 Root MSE = 0.18654

Download Throughput	Coef.	Std. Err.	t	P>|t|
Hawaii	3.018828	0.1537104	19.64	0.0000
Total Population	2.117983	0.0731723	28.95	0.0000
Percent Ethnically Hawaiian	-0.1576326	0.0538191	-2.93	0.0000
Percent Ethically Caucasian	0.1431909	0.0157993	9.06	0.0040
Percent with Bachelor Degree or Higher	1.043963	0.1482194	7.04	0.0000
Percent in Agricultural Industry	-1.222567	0.0245672	-49.76	0.0000
Per Capital Income	1.094507	0.0836963	13.08	0.0000
Percent of Homes Without Telephone Service	-0.8485853	0.0389359	-21.79	0.0000
Constant	-8.113577	0.8401439	-9.66	0.0000

Table 24

OLS Regression of Census Variables on Upload Throughput:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135	R-squared = 0.9955
F(8,129) = 5714.57	Adj R-squared = 0.9953
Prob > F = 0.0000	Root MSE = 0.01507

Upload Throughput	Coef.	Std. Err.	t	P>|t|
Hawaii	0.5957845	0.0285517	20.97	0.0000
Total Population	0.0467319	0.0022395	20.87	0.0000
Percent Ethnically Hawaiian	-0.0545381	0.0051645	-10.56	0.0000
Percent Ethically Caucasian	0.0327859	0.0015712	20.87	0.0000
Percent with Bachelor Degree or Higher	0.1372457	0.0147901	9.28	0.0000
Percent in Agricultural Industry	-0.2684751	0.0024127	-111.28	0.0000
Per Capital Income	0.1241279	0.0150977	8.22	0.0000
Percent of Homes Without Telephone Service	-0.1755959	0.003843	-45.69	0.0000
_Constant	-0.9613414	0.1145519	-8.39	0.0000

Table 25

OLS Regression of Census Variables on Round Trip Time:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135 | R-squared = 0.8709

F(7,129) = 174.12 | Adj R-squared = 0.8659

Prob > F = 0.0000 | Root MSE = 0.03842

Round Trip Time	Coef.	Std. Err.	t	P>|t|
Hawaii	1767.632	72.82186	24.97	0.0000
Total Population	-138.6487	5.711969	-24.27	0.0000
Percent Ethnically Hawaiian	-97.27254	4.007377	-24.07	0.0000
Percent with Bachelor Degree or Higher	-1140.695	60.28005	-18.92	0.0000
Percent in Agricultural Industry	84.88094	8.204811	10.35	0.0000
Per Capital Income	-874.5169	54.31897	-16.1	0.0000
Percent of Homes Without Telephone Service	97.39264	11.676	8.34	0.0000
Constant	7018.056	425.6195	16.49	0.0000

Table 26

OLS Regression of Census Variables on Network-Limited Time Ratio:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135	R-squared = 0.8839
F(6,129) = 196.45	Adj R-squared = 0.8794
Prob > F = 0.0000	Root MSE = 0.11001

Network-Limited Time Ratio	Coef.	Std. Err.	t	P>|t|
Hawaii	1.566858	0.2007521	7.8	0.0000
Percent Ethnically Caucasian	0.2289411	0.0114701	19.96	0.0000
Percent with Bachelor Degree or Higher	2.627562	0.1079713	24.34	0.0000
Percent in Agricultural Industry	-0.0493425	0.0176131	-2.8	0.0000
Per Capital Income	2.349932	0.1102171	21.32	0.0000
Percent of Homes Without Telephone Service	-0.6491278	0.0280547	-23.14	0.0000
Constant	16.87788	0.8362592	20.18	0.0000

Table 27

OLS Regression of Census Variables on Client-Limited Time Ratio:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135	R-squared = 0.3888
F(6,130) = 20.67	Adj R-squared = 0.3700
Prob > F = 0.0000	Root MSE = 0.15031

Client-Limited Time Ratio	Coef.	Std. Err.	t	P>|t|
Hawaii	-0.912377	0.1319235	-6.92	0.0000
Total Population	0.1900307	0.0257558	7.38	0.0000
Percent Ethnically Hawaiian	-0.0132572	0.0125491	-1.06	0.0000
Percent in Agricultural Industry	-0.460167	0.0618008	-7.45	0.0000
Per Capital Income	0.5898405	0.1124645	5.24	0.0000
Percent of Homes Without Telephone Service	-0.2325678	0.0254666	-9.13	0.0000
Constant	-5.202138	1.021897	-5.09	0.0000

Table 28

OLS Regression of Census Variables on Received Window Scale:

U.S. Pacific Territories, Hawaii, Puerto Rico, and U.S. Virgin Islands Dataset

Number of obs = 135	R-squared = 0.3888
F(6,130) = 17.14	Adj R-squared = 0.3250
Prob > F = 0.0000	Root MSE = 0.6742

Received Window Scale	Coef.	Std. Err.	t	P>|t|
Hawaii	2.75363	0.7702111	3.58	0.0000
Total Population	0.1154815	0.0404812	2.85	0.0050
Percent in Agricultural Industry	-1.083197	0.2828021	-3.83	0.0000
Percent of Homes Without Telephone Service	-0.619044	0.2782055	-2.23	0.0280
Constant	-1.284	0.914544	-1.4	0.0630

Table 29

Two-Sample Welch's t-Tests of Download Throughput:

Means for Mississippi - (minus) Means for American Samoa, Guam, the Commonwealth of the Northern Marianas Islands, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(MS) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
American Samoa	57	2.952054	55	15.643	1.0000	0.0000	0.0000
Guam	60	2.713602	58	19.9334	1.0000	0.0000	0.0000
CNMI	59	3.159475	57	23.0345	1.0000	0.0000	0.0000
Puerto Rico	60	2.085869	58	14.6858	1.0000	0.0000	0.0000
U.S. Virgin Islands	60	2.86003	58	21.0571	1.0000	0.0000	0.0000
Hawaii	56	0.2611968	54	1.5604	0.9377	0.1245	0.0623

Table 30

Two-Sample Welch's t-Tests of Upload Throughput:

Means for Mississippi - (minus) Means for American Samoa, Guam, the Commonwealth of the Northern Marianas Islands, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(MS) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
American Samoa	59	0.0017756	57	0.0338	0.5134	0.9732	0.4866
Guam	60	0.0564875	58	6.4031	1.0000	0.0000	0.0000
CNMI	60	0.1700393	58	13.2142	1.0000	0.0000	0.0000
Puerto Rico	60	0.0494011	58	6.189	1.0000	0.0000	0.0000
U.S. Virgin Islands	60	-0.0802804	58	-6.5526	0.0000	0.0000	1.0000
Hawaii	56	-0.3397267	54	-39.1596	0.0000	0.0000	1.0000

Table 31

Two-Sample Welch's t-Tests of Network-Limited Time Ratio:

Means for Mississippi - (minus) Means for American Samoa, Guam, the Commonwealth of the Northern Marianas Islands, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(MS) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
American Samoa	55	0.6767064	26.7409	17.8472	1.0000	0.0000	0.0000
Guam	55	0.0725	41.5866	7.6835	1.0000	0.0000	0.0000
CNMI	56	0.5910714	28.5894	22.2494	1.0000	0.0000	0.0000
Puerto Rico	56	0.5489286	53.7166	89.4539	1.0000	0.0000	0.0000
U.S. Virgin Islands	56	0.8717857	42.1908	94.1351	1.0000	0.0000	0.0000
Hawaii	56	0.0457143	46.9407	5.628	1.0000	0.0000	0.0000

Table 32

Two-Sample Welch's t-Tests of Client-Limited Time Ratio:

Means for Mississippi - (minus) Means for American Samoa, Guam, the Commonwealth of the Northern Marianas Islands, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(MS) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
American Samoa	55	-0.1524603	26.7457	-3.8636	0.0003	-	-
Guam	56	-0.0275	49.7184	-3.4836	0.0005	-	-
CNMI	56	0.3210714	52.6808	-3.1314	0.0005	-	-
Puerto Rico	55	-0.1443254	27.8712	-8.6236	0.0005	-	-
U.S. Virgin Islands	56	-0.2967857	42.3975	-55.2005	0.0000	-	-
Hawaii	56	-0.0446429	46.8908	-5.2574	0.0000	-	-

Table 33

Two-Sample Welch's t-Tests of Round Trip Time:

Means for Mississippi - (minus) Means for American Samoa, Guam, the Commonwealth of the Northern Marianas Islands, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(MS) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
American Samoa	55	-172.0026	26.3893	-14.6931	0.0000	0.0000	1.0000
Guam	56	-224.3929	27.7629	-26.2487	0.0000	0.0000	1.0000
CNMI	56	-280.6071	27.9295	-36.1784	0.0000	0.0000	1.0000
Puerto Rico	56	-31.11429	39.2369	-27.6931	0.0000	0.0000	1.0000
U.S. Virgin Islands	56	-54.17857	41.0919	-25.1688	0.0000	0.0000	1.0000
Hawaii	56	-31.82143	52.9852	-23.7906	0.0000	0.0000	1.0000

<u>Table 34</u>

Two-Sample Welch's t-Tests of Weighted Receiver Window Scale:

Means for Mississippi - (minus) Means for American Samoa, Guam, the Commonwealth of the Northern Marianas Islands, Puerto Rico, the U.S. Virgin Islands, and Hawaii

Territory/State	Combined Obs.	μ(MS) - μ(x)	Satterwaite's DF	t	Pr(T < t)	Pr(|T| > |t|)	Pr(T > t)
American Samoa	55	1.456852	27.9082	4.628	1.0000	0.0000	0.0000
Guam	56	0.6360714	52.809	6.9988	1.0000	0.0000	0.0000
CNMI	56	1.083571	53.9329	13.1594	1.0000	0.0000	0.0000
Puerto Rico	55	0.8214286	48.3503	11.3572	1.0000	0.0000	0.0000
U.S. Virgin Islands	56	0.9132143	43.8285	7.8469	1.0000	0.0000	0.0000
Hawaii	56	-0.0232143	50.8504	-0.3096	0.3790	0.7581	0.6210

Table 35

Indices of Poverty and Rurality: Mississippi, U.S. Pacific Territories, Puerto Rico, U.S. Virgin Islands, and Hawaii

	Mississippi (2010)	American Samoa (2000)	Guam (2000)	CNMI (2000)	PR(2000)	USVI((2000)	Hawaii (2000)
Percent of Workforce Employed	53.5	49.3	54.3	61.8	39.50	42.9	56.6
Percent Engaged in Agricultural Industry	2.9	3.1	0.5	1.5	1.40	0.7	2.3
Per Capita Income	19977	4,357	12,722	9,151	10056.00	13,139	21535
Percent of Families at or Below Poverty Level	16.7	58.3	20.0	30.6	41.40	28.7	7.6
Percent of Houses Without Telephone Service	5.9	31.7	6.7	29.9	17.90	8.1	2