Project factsheet information

Project title	A Peering Strategy for the Pacific Islands
Grant recipient	Telco2 Limited 27 Austin Street, Mount Victoria, Wellington 6011, New Zealand +64 4 913 8123 http://telco2.co.nz/ http://pacpeer.org/
Dates covered by this report	01 – 05 – 2015 / 15 – 09 – 2016
Report submission date	30 – 09 – 2015
Country where project was implemented	New Zealand
Project leader name	Jonathan Brewer
Team members (list)	
Partner organizations	The University of Oregon's Network Startup Resource Center.
Total budget approved	$30,000 AUD
Project summary	This project will catalogue demand, commercial arrangements, infrastructure, policies, and monopolies throughout the Pacific. It will educate stakeholders on the commercial, technical, and performance issues around overseas interconnections. The strategy proposed will help stakeholders to solve their own problems. The strategy is unlikely to call for peering in every country; few Island nations have the traffic to support them. It will instead try to inform stakeholders how regional cooperation can be of benefit to all.

Table of Contents

isif asia

This work has been developed with the support provided by the Information Society Innovation Fund (ISIF Asia) – 2015, licensed under the Creative Commons Attribution-ShareAlike 4.0 International.

Background and Justification

Most telecommunications networks in the Pacific interconnect in Asia, Australia, or the United States. This has a profound impact on both the cost and the performance of regional traffic. It discourages regional interactions, and in particular erects barriers to research and education.

Many stakeholders in the Pacific do not fully understand the impact overseas interconnection has. Few look beyond the problems of their own country or organisation. This lack of understanding perpetuates cost and performance problems for all users. In some cases, it significantly lessens the impact of new submarine cable infrastructure.

Several cases illustrate the difficulties of the Pacific.

Most Samoan traffic between providers and universities routes via the United States. Technical workers at three providers and two universities are interested in establishing an exchange. No progress on an exchange has been made as managers do not recognise a business case.

Many students at the University of South Pacific (USP) in Fiji access campus resources from home via Vodafone. All traffic between Vodafone Fiji and USP routes via Australia. The overseas interconnection results in slow speeds and frustrations for students and network administrators. USP set up a temporary peering exchange with Vodafone in 2013 that vastly improved performance. Unfortunately the exchange was disestablished for political reasons.

Paupa New Guinea has two submarine cables connected to two different telecommunications providers. The providers do not have a local interconnection. A local Internet Exchange Point has had the support of local and overseas stakeholders since 2010. PNG's regulator started investigating the issue in 2012. Still to this day there isn't a local exchange point. Traffic between providers exchanges overseas.

Vanuatu was the Pacific's only Internet Exchange success story. The Vanuatu Exchange launched around the same time as a new submarine fibre cable connected the country to Fiji. For a time, traffic between Vanuatu providers and government agencies stayed local to Vanuatu. Traffic from Vanuatu to Fiji however travels via Australia.

This project will catalogue demand, commercial arrangements, infrastructure, policies, and monopolies throughout the Pacific. It will educate stakeholders on the commercial, technical, and performance issues around overseas interconnections.

The strategy proposed will help stakeholders to solve their own problems. The strategy is unlikely to call for peering in every country; few Island nations have the traffic to support them. It will instead try to inform stakeholders how regional cooperation can be of benefit to all.

Project Narrative

Project Objectives

The project's original objectives remain unchanged. They include a thorough examination and documentation of:

1. Physical and routed topology of the Internet in the Pacific
2. Demand from major users including commercial networks, education, and government
3. A matrix of stakeholders with ties across island nations, highlighting those with the most to gain
4. Analysis of benefits these to stakeholders of peering
5. Barriers to the efficient routing and exchange of traffic in the Pacific
6. A strategy for the establishment of peering exchanges

Project Partnerships

The University of Oregon's Network Startup Resource Center (NSRC) has been a valuable partner to the project, allowing the project leader to combine project research while travelling to the Pacific to teach network engineering and to provide direct engineering assistance to educational institutions. The NSRC has also provided introductions to key stakeholders throughout the Pacific, including commercial, education, and government organisations involved in the development or regulation of telecommunications services.

The Pacific Islands Telecommunications Association (PITA) has been a valuable partner to the project, providing introductions to commercial carriers, and encouraging Pacific carriers to participate in the research through interviews and hosting of RIPE Atlas probe infrastructure.

The Pacific Islands Regulatory Resource Centre has been a valuable partner to the project, as a source, providing introductions, and providing office space for the project while the project leader was working in Fiji.

Although APNIC and ICANN were made aware of the project, they were not forthcoming in details on their Pacific activities and several opportunities for collaboration were missed. APNIC held trainings in Niue several weeks after the project leader visited Niue. ICANN held a series of trainings in Micronesia around two months before the project leader visited Guam for PacNOG18. These trainings would have been an ideal time for the project leader to attend and meet with stakeholders on Niue and in Micronesia, and explain to them the benefits of participating in the Peering Strategy project.

Involvement of Beneficiaries

Potential beneficiaries of the project include end users, governments, and carriers. More than 30 potential beneficiaries have agreed to be interviewed by the project leader, and have in aggregate provided more than 50 hours of time supplying background information.

Gender, Ethnic, Generation Gap

The Pacific is made up of a multitude of ethnic groups, all of whom seem to value participation from all ages of stakeholders. Ethnic or generation gap issues have had no impact on the project at all. From a gender perspective, it has been difficult to find women involved in the technical operations, management, or regulation of telecommunications providers. As this reflects the makeup of the telecommunications industry in Western nations, unclear whether or not a gender gap has had an impact on the project.

Adjustment of Activities

Development of tools and dissemination of project information has come slower than expected. Blogging about tasks and project updates has not been done on the internal project management website. That website has however expanded far beyond its original scope, and has become a resource now used by external parties such as the Pacific Islands Regulatory Resource Center.

Due to the timing of the grant disbursement, a planned visit to Tonga was not achieved. Instead a visit to Niue was substituted. Some trips have been less expensive than planned, and some more expensive. Overall, travel plans and spend on travel has been adjusted to suit the projects objectives.

Sensitivities around the recording of conversations have meant that proposed transcription services have not been used – instead typed notes have been taken of each interview. Additional in-person and Skype or Google Hangout interviewing has led to a vastly reduced telecoms budget.

Cable topologies, commercial arrangements, and educational partnerships discovered in early research has led to an increase in the amount of cloud servers for monitoring Internet latency. A server in Seoul was added to test claims by come carriers of transit supplied via Korea Telecom. A server in Mumbai was added to measure performance between India and Fiji, to investigate claims by Fiji National University of performance problems related to their Internet transit. Servers were added in Auckland, Seattle, and Los Angeles at major exchange points to determine how some Pacific carriers were engineering their traffic.

Indicators

Indicators	Baseline	Progress assessment	Course of action
Each of a set of countries in the Pacific was to be evaluated per the first four objectives, resulting in a matrix of stakeholders across the Pacific and an analysis of the benefits of peering for them.	At the start of the project, no significant work had been done to investigate the situations of the countries below: • American Samoa • Australia • Cook Islands • Federated States of Micronesia • Fiji • French Polynesia • Guam • Hawaii • Kiribati • Marshall Islands • Nauru • New Caledonia • New Zealand • Niue • Papua New Guinea • Samoa • Solomon Islands • Tonga • Tuvalu • Wallis and Futuna	Economics research on all of the Pacific markets has been done. Detailed investigations of telecommunications infrastructure has been carried out for all countries except: Kiribati, Nauru, Papua New Guinea, Tuvalu, Wallis and Futuna. In-person interviews have been carried out with all nine carriers in Pacific hubs Guam and Fiji, and with some providers in American Samoa, Cook Islands, French Polynesia, Hawaii, Niue, and Samoa Performance monitoring systems have been established for all islands except Tuvalu and Wallis and Futuna. RIPE Atlas probes have been installed in around 30 autonomous systems in the islands, out of a target of 70 systems.	No significant changes are proposed. Participation in the PITA meeting and at PTC in Honolulu in January has lead to more interviews and more potential interviews with stakeholders, and higher penetration of RIPE Atlas probes.
A set of tools showing stakeholders the benefits of peering will be created as part of the project.	Before the start of the project, a few performance monitoring servers had been established in an ad-hoc and largely undocumented manner.	Fifteen servers are currently gathering data that will support the tools being created. All have been given standard configurations and security measures. Documentation on their configurations and commercial arrangements has been produced. An automated configuration system has been written allowing secure, automated addition of targets for the performance system. No aggregation of data from the servers is happening yet, and no single front-end server exists to share the collected performance data.	A website with information on the networks in the pacific has been created and will be released in November 2016. Data aggregation services and real-time data display on that website has been shifted into a new project funded by an operational research grant from APNIC.
A strategy for the establishment of peering exchanges	Prior to the launch of the project, some Pacific countries had been exposed to presentations and workshops around peering, including Vanuatu, Samoa, and Papua New Guinea.	Presentations about the present situation of peering in the Pacific have been given in Samoa, Tahiti, Niue, Fiji, Guam, and Hawaii, to a wide variety of stakeholders.	Many solutions to the problems encountered in the Pacific have been researched, documented and discussed in conference talks. While a strategy document is still important to the project, it is evident that communicating strategies will require the development of sets of training materials aimed at providers, regulators, and education users.

isif asia

This work has been developed with the support provided by the Information Society Innovation Fund (ISIF Asia) – 2015, licensed under the Creative Commons Attribution-ShareAlike 4.0 International.

Project implementation

Project activities	Input	Outputs	Timeline	Status
Establish additional monitoring servers.	Server configuration and documentation.	Measurement collection and management documents.	June 2015-October 2015	Completed
Establish Confluence document management system instance.	System configuration.	Common document management store for all research materials and technical documentation.	August 2015	Completed
Improved Cable Latencies documentation.	Information gathering from vendors, maps, and online resources.	Cable latency charts used for benchmarking actual results.	October 2015	Completed
Airports and air routes of the Pacific.	Information gathering from online databases.	A traffic and efficiency metric for air travel in the Pacific, to compare data traffic to.	August 2015 – June 2016	Completed[1]
Server security hardening and Smokeping update automation.	Configuration files, and scripts.	Secure servers and a process for updating all servers at once. Scripts stored in NSRC git repository.	October 2015	Completed
Interviews.	In-person or Skype interviews with stakeholders.	More than 30 sets of meeting notes and 15 emails stored in Confluence	May 2015 – June 2016	Completed
Kanban board.	Migrate reminders, paper notes, and emails into a coherent list of questions to ask for the project, and who to ask to get them answered.	Kanban board located in the administration section of the Confluence site	September 2015	Completed
Visit to Auckland for PicISOC meeting and NetHui.	Travel to Auckland. Presentation to PicISOC. Participation in PicISOC and NetHui.	Raise awareness of project and issues around peering in the Pacific. Find potential collaborators and interviewees.	July 2015	Completed
Visit to Samoa for PacNOG17 with NSRC	Travel to Samoa. Presentation to and participation in the PacNOG17 conference and training.	Raise awareness of project and issues around peering in the Pacific. Informal interviews with Samoa and American Samoa providers. Agreement to collaborate with PITA.	July 2015	Completed
Visit to Tahiti and Moorea with NSRC	Travel to French Polynesia. Meet with OPT, CRIOBE, University of California. Presentation to University of California.	Understand the telecommunications environment in French Polynesia – in particular how it affects research and education.	August 2015	Completed
Visit to Rarotonga	Personal visit to Rarotonga on which an interview with BlueSky CEO Adolfo Montenegro was conducted.	Understand the telecommunications environment in the Cook Islands, and how Telecom Cook Islands is being integrated into a regional network with BlueSky Samoa and American Samoa	August 2015	Completed
Visit to Australia for AusNOG	Travel to Australia. Meet with AARNet in Sydney before continuing on to AusNOG in Melbourne. Formal interview with AARNet. Presentation at the AusNOG conference. Informal interviews with Australian carriers.	Raise awareness of project and issues around peering in the Pacific. Understand Australian carriers relationships with the Pacific. Understand AARNet Pacific efforts.	September 2015	Completed
Visit to Niue	Travel to Niue. Meet with NZ High Commission, IUSN, Rocket Systems, Telecom Niue, AISCorp, IUSN end users. Formal interviews with all parties except Telecom Niue and AISCorp (informal interviews conducted)	Raise awareness of project and issues around peering in the Pacific. Understand the telecommunications environment in a satellite fed country.	September 2015	Completed

1 https://kiwibrew.carto.com/viz/19ece3ca-7d86-11e6-ab30-0ee66e2c9693/map

isif asia

Project activities	Input	Outputs	Timeline	Status
Visit to Fiji	Travel to Fiji. Meet with PITA, PIRRC, Telecom Fiji, Vodafone Fiji, Fintel, Digicel Fiji, Fiji National University, University of the South Pacific, Fiji Telecoms regulator (TAF)	Raise awareness of project and issues around peering in the Pacific. Understand the telecommunications environment in Fiji – in particular international transit issues. Agreement to work with PIRRC including sharing of pre-publication project materials and background research.	October 2015	Completed
Meeting with Jules Maher in Wellington, NZ	Interview Jules in his capacity as advisor to the government of Niue and board member of Our Telkom, Solomon Islands	Raise awareness of project and issues around peering in the Pacific. Understand political difficulties in Niue between government owned telco & private carrier funded by .nu.	November 2015	Completed
Meeting with Emanni Lui in Auckland, NZ	Interview Emanni in his capacity as owner of Rocket Systems, Niue	Raise awareness of project and issues around peering in the Pacific. Understand political difficulties in Niue between government owned telco & private carrier funded by .nu.	November 2015	Completed
Visit to Guam for PacNOG18 with NSRC	Travel to Samoa. Presentation to and participation in the PacNOG18 conference and training. Formal and informal interviews with carriers from Guam, FSM, Palau, Republic of the Marshall Islands.	Raise awareness of project and issues around peering in the Pacific. Understand the Guam market in its context as a North Pacific hub for submarine cables.	December 2015	Completed
Visit to Hawaii for PITA Meeting & Pacific Telecommunications Council.	Travel to Hawaii. Presentation to and participation in PITA Meeting, PTC, Pacific RANET planning meeting. Formal interviews with University of Hawaii (x2), Hawaii Pacific Teleport, Asia Development Bank. Informal interviews with carriers and regulators from multiple markets	Raise awareness of project and issues around peering in the Pacific. Understanding of the Hawaii Internet market, in particular submarine fibre optic services, landing station access, and terrestrial transit market.	January 2016	Completed
Documentation and Mapping of Shipping Routes	Route maps from Asia Development Bank study on shipping in the Pacific	Determine how physical goods move through the Pacific for comparison with air traffic and data.	July – September 2016	Completed[2]
Documentation and Mapping of Submarine Cables	Multiple sources including US Govt nautical charts.	Determine how data moves through the pacific for comparison with air traffic and physical goods.	July – September 2016	Completed[3]
Visit to PNG for PacNOG19	Travel to PNG. Present to and participate in pacNOG19 conference and training. Formal and informal interviews with local carriers & govt.	Raise awareness of project and issues around peering in the Pacific. Understand PNG market & its connections to Australia & SE Asia.	July 2016	Cancelled due to political unrest.

Communications and Dissemination

Most of the activities described above involved the dissemination of project materials. By virtue of visiting many locations and attending a large number of meetings, people from a wide range of ages, ethnicities, and socio-economic profiles were connected with. No particular effort was made to target different gender groups.

The project has been communicated via multiple meetings and conferences, and via social media including Facebook and Twitter. A website is available at http://pacpeer.org/ and seven presentations have been published there.

2 https://kiwibrew.carto.com/viz/19ece3ca-7d86-11e6-ab30-0ee66e2c9693/map

3 https://kiwibrew.carto.com/viz/19ece3ca-7d86-11e6-ab30-0ee66e2c9693/map

Project Management and Sustainability

Project administration has been achieved by taking advantage of a set of cloud-based software tools. Atlassian's Confluence system has been used as a Wiki, document store, annotation tool, and Kanban board. Minutedock has been used for time tracking. Xero has been used to manage project finances.

Through meetings and communications with the Pacific Islands Telecommunications Association (PITA) and the Pacific ICT Regulatory Resource Centre (PIRRC) it has been generally agreed that the project principles need to live on after the project is completed. To this end, an interconnection committee has been discussed, and may be permanently created within PITA. The PIRRC plans to integrate project findings into training workshops aimed at regulators and regulatory staff in the Pacific. Through these two groups, stakeholders in provider and government spaces will be continually engaged on achieving project goals after the completion of the project.

In May 2016 a formal plan for integrating real-time data into the project was developed, and proposed to APNIC's operational research grants program. Their funding, confirmed in August 2016, will allow systems developed to provide ad-hoc querying capabilities to be fully automated. The automated data will help users, operators, and governments make decisions with regards to the purchase, interconnection, and regulation of Internet services. Data systems are planned to be live on the existing PacPeer website within four months of the start of the new project.

Project Outcomes and Impact

Project activities	**Project Outcomes**
Latency Baselines and Monitoring System	All stakeholders will understand the performance of their local carriers to regional and world destinations. In the medium-term, this may lead to decisions by users to purchase one service over the other. It could lead to decisions by regulators to encourage or discourage carrier behaviours. Finally it could lead to carriers making architectural and commercial decisions that could benefit all stakeholders and regional interconnectivity. Stakeholders who have listened to or read presentation decks (greater than 80% of Pacific carriers) have gained visibility of latency issues.
Document Repository	The document repository assembled through this project could be a valuable resource for all stakeholders to understand technical, commercial, and regulatory challenges that have resulted in the state of Pacific interconnectivity in 2016. Its integration into PIRRC resources could create a unique permanent resource of materials relevant to the project's goals. The Document Repository will be continued for at least another three years via an APNIC Operational Research Grant.
Stakeholder Interviews	Perspectives on networking and interconnectivity are often not shared even within small markets. Publishing mini case-studies based on stakeholder interviews could lead to greater understanding within markets, and realisation throughout the region that many interconnectivity problems are not market-unique, but common across small island developing states. No stakeholder Interviews or case studies have been published aside from anecdotes documented in slide notes published on the PacPeer website.
Presentations	Every formal presentation of the project material has raised awareness of the issues of peering in the Pacific and potential solutions. Through presentations at conferences, PITA and PIRRC have committed to continuing the project goals. Audience members have offered interviews and stories, contributing background material that otherwise would not have been available. Carriers have asked how they can do better, regulators have asked how they can participate, and funders such as the Asia Development Bank have agreed to open dialogue.

isif asia

This work has been developed with the support provided by the Information Society Innovation Fund (ISIF Asia) – 2015, licensed under the Creative Commons Attribution-ShareAlike 4.0 International.

Overall Assessment

The following table considers the project objectives and the extent to which they have been met.

Project Objective	Extent Met
Physical and routed topology of the Internet in the Pacific	Multiple static pictures of Internet topology in the Pacific have been captured and presented. A unified front-end to display dynamic and point-in-time pictures has been planned and will be built as part of a new project.
Demand from major users including commercial networks, education, and government	Interviews with stakeholders have captured and documented demand from commercial networks, education users, and governments for better local and regional interconnectivity.
A matrix of stakeholders with ties across island nations, highlighting those with the most to gain	A number of cross-island stakeholders have been identified. External research on Pacific markets and economies has introduced some surprising results into the project – ties between islands and OECD economies have been stronger than expected. As a result, the matrix will be expanded to show how connectivity between islands and their major trading partners functions.
Analysis of benefits these to stakeholders of peering.	Interviews have established immediate benefits of local and regional peering to a number of commercial, education, non-government organisations, and carriers.
Barriers to the efficient routing and exchange of traffic in the Pacific	Interviews and research have established a number of barriers to the efficient routing and exchange of traffic in the Pacific. Competitive access to cable landing stations and terrestrial transit at hub sites in Fiji, Guam, and Hawaii in particular have been established as key barriers. Commercial regulation established in Fiji in favour of its cable landing station operator has also been established as a key barrier.
A strategy for the establishment of peering exchanges	A number of strategies have been identified. Developing materials to communicate these strategies is a major focus of the project in its final months.

While users are experiencing problems due to routing inefficiencies, their carriers and governments do not necessarily understand user problems. Carriers understand “more capacity” to be the solution to most issues. Governments think “lower costs” is the solution for better performance for users. The lack of understanding by both governments and carriers of how efficient network interconnections can solve end user problems is the most important finding of the project to date – and educational materials will be developed to address it.

Any improvement to the efficiency of Internet connectivity in small island developing states has a flow-on effect to multiple areas of development. Should any stakeholders adjust their behaviour based on outputs of this project it should be considered a contribution to development.

In-person interviews – both formal and informal – have been of exceptional importance to the success of the project. While the initial project design called for telephone interviews, it was apparent shortly into the project that the culture of many Pacific island nations is more supportive of in-person interactions, certainly for first contacts

Recommendations and Use of Findings

Stakeholders identified include end users, governments and regulators, and carriers. The desired change is an improvement in performance and cost for all stakeholders, achieved via more efficient network interconnections.

Today end users don’t know where to turn for information about telecommunications in the Pacific. If provided with appropriate resources and training, end users will be able to take into account the performance of their carriers when requesting services from their carriers or making purchasing decisions. With the assistance of organisations such as PicISOC the results of this project and its resources can be communicated to users.

isif asia

Governments and regulators in the Pacific look to established markets and attempt to match their regulatory regimes, with the expectation that their own markets will respond in the same way. With the right information, governments will understand that markets in the Pacific need attention not required in continental markets. They might then cooperate on a regional basis on strategies to ensure Internet services are delivered in technically and cost-efficient manners. The PIRRC can help ensure governments and regulators have the information they need to cooperate and benefit their constituencies.

Carriers typically value profit above all other metrics, and the simplest equation of profit for carriers involves low-cost Internet transit. With education on purchasing and interconnection strategies, assisted by industry groups such as PITA, carriers might begin to work together to achieve efficiencies with transit and caching that they could not otherwise gain on their own. Such efficiencies will achieve the dual goal of improving performance for end users while also increasing profit margins.

Three distinct stakeholder groups require the creation of three different strategies in order to achieve the change the project wishes to bring about. With the assistance of three external organisations it is likely the project will succeed in its goals.

Bibliography

Aben, E. (2015, July 2). Improving RIPE Atlas Coverage - Which Networks Are Missing?. Ripe NCC. Retrieved from https://labs.ripe.net/Members/emileaben/improving-ripe-atlas-coverage-what-networks-are-missing

Aben, E. (2015, March 23). Measuring Countries and IXPs with RIPE Atlas. Ripe NCC. Retrieved from https://labs.ripe.net/Members/emileaben/measuring-ixps-with-ripe-atlas

Anderson, P. K., & Suwamaru, J. K. (2011). PPC-1 Sydney-Guam PIPE pacific cable: New internet gateway for PNG via Madang. Contemporary PNG Studies, 15, 1 – 20.

Angwin, J., & Larson, J. (2015, August 15). A Trail of Evidence Leading to AT&T's Partnership with the NSA. ProPublica. Retrieved from https://www.propublica.org/article/a-trail-of-evidence-leading-to-atts-partnership-with-the-nsa

Asian Development Bank. (2015). North Pacific Regional Connectivity Investment Project: Report and Recommendation of the President (Project Number: 46382-001). Retrieved from https://www.adb.org/projects/documents/pal-north-pacific-regional-connectivity-investment-project-rrp

Asian Development Bank. (2016). North Pacific Regional Connectivity Investment Project: Procurement Plan (Project Number: 46382-001). Retrieved from https://www.adb.org/projects/documents/pal-north-pacific-regional-connectivity-investment-project-pp

AT&T. (2016). Global Network Latency Averages. ipnetwork. Retrieved from https://ipnetwork.bgtmo.ip.att.net/pws/global_network_avgs.html

Audio Productions, Inc. (Producer). (2011, March 3). C.S Long Lines [Video file]. AT&T Archives and History Center, Warren, NJ. Retrieved from http://techchannel.att.com/play-video.cfm/2011/3/21/AT&T-Archives-CS-Longlines

Australia Japan Cable (n.d). Guam Landing Points. Retrieved from http://www.ajcable.com/guam-landing-points/

Bagnol, R. C. (2013, July 22). IT&E: We're not a monopoly. Marianas Variety. Retrieved from http://www.mvariety.com/cnmi/cnmi-news/local/57646-it-e-we-re-not-a-monopoly

Bakhshi, B., Manna, M., Mohs, G., Kovsh, D. I., Lynch, R. L., Vaa, M., ... & Jiang, S. (2004). First dispersion-flattened transpacific undersea system: From design to terabit/s field trial. Journal of lightwave technology, 22(1), 233.

Barnett, W. C., Takahira, H., Baroni, J. C., & Ogi, Y. (1996). The TPC - 5 Cable Network. IEEE Communications, 36 - 40.

Bejado, C. Y. (2010, January 17). GTA TeleGuam Expands Capacity for Trans-Pacific Communications. Business Wire. Retrieved from http://www.businesswire.com/news/home/20100117005007/en/GTA-TeleGuam-Expands-Capacity-Trans-Pacific-Communications

Botha, G. D (2014). In the Appeal of Pacific Data Systems Inc. Guam: Office of Public Accountability.

Bressie, K. (2009). Cable Landing License Held by Tyco Telecommunications (US) Inc., FCC File No. SCL-LIC-20050304-00011. Wiltshire & Grannis, Washington, USA.

Bressie, K. (2014). PTC'14 Undersea Cable Regulatory Update [Powerpoint Presentation]. Wiltshire & Grannis, 1-11.

Bressie, K. D. (2012). Applications Filed for the Transfer of Control of Wavecom Solutions Corporation to Hawaiian Telcom, Inc. Washington, USA: Federal Communications Commission.

Brooks, D. F (2013NOV13). Decision and Order Re Purchasing Agency's Motion to Dismiss for Lack of Jurisdiction. Guam: Office of Public Accountability.

Brooks, D. F (2013NOV21). In the Appeal of Teleguam Holdings, LLC and its Wholly Owned Subsidaries, GTA Telecom LLC; GTA Services, LLC; and Pulse Mobile, LLC. Guam: Office of Public Accountability.

Brooks, D. F (2015). In the Appeal of Pacific Data Systems Inc. Guam: Office of Public Accountability.

Brooks, D. F. (2013). Procurement Appeals 12-016, 12-017 and 12-018 Consolidated Decisions. Hagåtña, Guam.

Brooks, D. F. (2014). Procurement Appeals OPA - PA - 13 - 016. Hagåtña, Guam.

Brooks, D. F. (2015). Procurement Appeals OPA - PA - 14 - 013. Hagåtña, Guam.

Brumley, R. [Pacific Telecommunications Council]. (2014, March 27). PTC'14 Keynote 2-2 - Laser Light Communications: Bringing the World the Power of Light™ [Video file]. Retrieved from https://www.youtube.com/watch?v=NKKnLy_ewG0

Buckley, S. (2014, January 23). Tata lights up 100G services on TGN-P cable route linking U.S., Asia and Japan. Fierce Telecom. Retrieved from http://www.fiercetelecom.com/telecom/tata-lights-up-100g-services-tgn-p-cable-route-linking-u-s-asia-and-japan

Burger, T. (2015, February 9). How Fast is Realtime? Human Perception and Technology [Web log post]. Retrieved from https://www.pubnub.com/blog/2015-02-09-how-fast-is-realtime-human-perception-and-technology/

Burrington, I. (2015, November 12). Where the Cloud Rises From the Sea. The Atlantic. Retrieved from http://www.theatlantic.com/technology/archive/2015/11/where-the-cloud-rises-from-the-sea/415236/?utm_source=SFTwitter

Cagurangan, M. (2013, April 15). Lawsuits stall GovGuam telecom contract anew. The Guam Daily Post. Retrieved from http://www.postguam.com/news/local/lawsuits-stall-govguam-telecom-contract-anew/article_50d292fa-935c-59fa-8758-75d1cb235d4b.html

Cagurangan, M. (2012, September 2). NTT Docomo to buy MCV. Marianas Variety. Retrieved from http://www.mvariety.com/cnmi/cnmi-news/local/49334-ntt-docomo-to-buy-mcv.php

Calabrese, M., Calarco, D., & Richardson, C. (2012, May 16). The Most Expensive Internet in America [Web log post]. Retrieved from http://www.slate.com/blogs/future_tense/2012/05/24/internet_access_and_cost_in_american_samoa_northern_marianas_islands_guam_.html

Caldwell, B. (2004, July 7). Grant eyed for new fiber optic cable. Retrieved from http://www.saipantribune.com/index.php/9fe12116-1dfb-11e4-aedf-250bc8c9958e/

Camacho, V., Nishihira, F. S., Camacho, A. R., & Mann, B. R. (2015). Teleguam Holdings, LLC v. Territory of Guam, 2015 Guam 13, Opinion. Hagåtña, Guam: Supreme Court of Guam.

Carlisle, T. (2008). Application for a License to Land and Operate a Private Fiber-Optic Cable System Connecting Australia, Guam, and Papua New Guinea, for the PPC1 System. Washington, USA: Federal Communications Commission.

CenturyLink IQ (2011). Networking Service Level Agreement International Private Port Latency Goals attachment 2 (version 1), 1-2.

Clark, N. (2015, September 1). AusNOG 2015: meeting continues to impress [Web log post]. APNIC. Retrieved from https://blog.apnic.net/2015/09/01/ausnog-2015-meeting-continues-to-impress/

Clesca, B. (2014, January 20). Palau Telecoms Selects Xtera for the Turnkey Supply of the Palau – Guam Submarine Cable System [Web log post]. Xtera. Retrieved from http://www.xtera.com/palau-telecoms-selects-xtera-for-the-turnkey-supply-of-the-palau-guam-submarine-cable-system/

Cognet Communications Inc. (2016). IP Network Performance Statistics. Cognet. Retrieved from https://www.cogentco.com/en/network/performance

Commonwealth HealthCare Corporation (2013). Commonwealth of the Northern Mariana Islands State Medicaid Health Information Technology Plan (SMHP) (version 3). Commonwealth of the Northern Mariana Islands, USA.

Cooper, T. J. (2014). IPLC QUOTE: 1Gb Full Channel Guam-Hi, Guam LL on AAG. IT & E Life in Motion, 1.

Cousins, M. (2015, September 8). Pacific's 'Future Leaders' Gather in Auckland. U.S Embassy & Consulate in New Zealand. Retrieved from https://nz.usembassy.gov/pacifics-future-leaders-gather-in-auckland/

Cunliffe, F. R., Clark, A. B., Torres, R. J., & Limtiaco, A. A. G. (2002). Carlson v. GTA, Opinion. Hagåtña, Guam: Supreme Court of Guam.

DatacenterDynamics. (2008, January 28). GTA TELEGUAM announces grand opening of the new Asia Pacific Datacenter (APAC). Retrieved from http://www.datacenterdynamics.com/gta-teleguam-announces-grand-opening-of-the-new-asia-pacific-datacenter-apac/55120.fullarticle

Dawson, W. (2000). Affidavit of S. Wallace Dawson, Jr. Federal Communications Commission. Washington, USA.

Day, J. (2015). Notice of Appeal Form Procurement Appeal Pacific Data Systems, Inc. Guam.

di Lallo, R. (2015, August 3). Is It Really Worth Peering at IXPs? A Comparative Study. Ripe NCC. Retrieved from https://labs.ripe.net/Members/roberto_di_lallo/is-it-really-worth-peering-at-ixps

Dumat-ol Daleno, G. (2015, July 11). Undersea cable break offers lessons for Guam, world. Pacific Daily News. Retrieved from http://www.guampdn.com/story/news/2015/07/10/undersea-cable-break-offers-lessons-guam-world/29950811/

Eckel, J. W. (2008). Application for a License to Land and Operate a Private Fiber-Optic Cable System Connecting the U.S. Army Kwajalein Atoll/Reagan Test Site, in the Republic of the Marshall Islands, and Guam for the Hantru1 System. Washington, USA: Federal Communications Commission.

Eugenio, H. V. (2010, April 6). IT&E gets $8M ARRA grant. Saipan Tribune. Retrieved from http://recovery.gov.mp/2010/04/ite-gets-8m-arra-grant/

Feagaimaalii-Luamanu, J. (2015, March 3). ASTCA fiber optic and O3b services to begin soon. Retrieved from http://www.samoanews.com/content/en/astca-fiber-optic-and-o3b-services-begin-soon

Federal Communication Commission. (2001). IT&E Overseas, Inc. Petition for Designation as an Eligible Telecommunications Carrier in the Territory of Guam. Federal Register, 6(244), 65502.

Federal Communications Commission (2015). Streamlined Submarine Cable Landing License Applications Accepted for Filing. Washington, USA.

Federal Communications Commission. (2012). Applications Filed For The Transfer Of Control Of Subsidiaries Of Mcv Guam Holding Corp. To Docomo Guam Holding Inc: Comments of One Economy Corporation one Global Economy. Federal Communications Commission. Washington, USA.

Fishman, E., & Bressie, K.D. (2010). Office des Postes et Telecommunications de Polynesie francaise; File Nos. SCL-LIC-20081008-00017 and ITC-214-20081008-0045. Washington, USA: Federal Communications Commission.

Glover, B. (2012). History of the Atlantic Cable & Undersea Communications from the first submarine cable of 1850 to the worldwide fiber optic network. Retrieved from http://atlantic-cable.com/Cables/CableTimeLine/index2001.htm

Ha, M. (2016, July 25). AAE-1 undersea cable to operate in Vietnam this year. Retrieved from http://english.vietnamnet.vn/fms/science-it/159438/aae-1-undersea-cable-to-operate-in-vietnam-this-year.html

Hart, T. (2011, March 2). Guam broadband use to be mapped, studied. Retrieved http://www.postguam.com/news/local/guam-broadband-use-to-be-mapped-studied/article_1ef24634-315e-5113-9ef8-b11754a8d6c3.html

Hawaii Pacific Teleport (n.d). Satellite Coverage [Graph of possible coverage from HPT teleport via multiple satellites]. Retrieved from http://www.hawaiiteleport.com/index.php/satellite-coverage

Hawaii's Internet access high (n.d). Retrieved from http://archives.starbulletin.com/content/20100219_Hawaiis_Internet_access_high_but_usage_among_nations_lowest

Hayakawa, Rieko. "Self-Determination for the Communication Policy in the Pacific Islands." Self-determinable Development of Small Islands. Springer Singapore, 2016. 179-202.

Heap, S., & Paradis, (2016, July). A world without termination rates - reality or fiction. Retrieved from http://www.hottelecom.com/articles/articles-July-2016.html

Hinirat, A. S. (2012). Revised Bid Status Telecommunication Services. Agana, Guam: General Service Agency.

Ho, D., & Calarco, D. (2013, March 8). Broadband returns to the Guam Public Library System Branches [Web log post]. Retrieved from http://broadbandmapguam.blogspot.co.nz/2013/03/broadband-returns-to-guam-public.html

Holland, E. (2013). Director Pace - SD Professor Elisabeth Holland. Suva, Fiji: The University of the South Pacific.

Horecky, F. J. (2015). Guam Telecom, LLC USAC Certification GT Docket 15-01 PUC Counsel Report. Guam: Guam Public Utilities Commission.

International Cable Protection Committee. (2015, May 21). Scientific Cables. Retrieved from https://iscpc.org/cable-data/scientific-cables/

Internet World Stats. (n.d). Wallis and Futuna Islands Statistics. Retrieved from http://www.internetworldstats.com/pacific.htm#wf

IT & E Life in Motion (2010, June 16). IT&E Increases Asia-Pacific Bandwidth Capacity. Retrieved from https://www.ite.net/news_and_info.cfm?vzid=3

IT & E Life in Motion (2011, January 06). IT&E upgrades quadruples peak load speed. Retrieved from https://www.ite.net/news_and_info.cfm?vzid=5

IT & E Life in Motion (2011, January 26). IT&E on track with infrastructure upgrades using ARRA funds. Retrieved from https://www.ite.net/news_and_info.cfm?vzid=6

Jaynes, B. (2009, November 25). Undersea Fiber Optic Cable Arrives In Pohnpei. Pacific Islands Report. Retrieved from http://archives.pireport.org/archive/2009/november/11-25-09.htm

Kabua, A. (2014). Country Report on IP/ISP Network [PowerPoint Presentation]. Marshall Islands National Telecommunications Authority.

Kuerht, L. (2010). Justification for other than Full and Open Competition NTIA Award #NT10BIX5570053. IT & E Life in Motion, 1-3.

Kuipers, K. (2015, July 27). Analysing the K-root Anycast Infrastructure. Ripe NCC. Retrieved from https://labs.ripe.net/Members/jh_kuipers/analyzing-the-k-root-anycast-infrastructure

La Fibre, (2015). Multinode Deployment Guide, Release. Google Global Cache.

Labour & Immigration Research Centre (2012). Population Movement in the Pacific: A Perspective on Future Prospects. Wellington, New Zealand.

Licanto, N. (2015, October 19). Visitor numbers for Japan fall flat. Retrieved from http://www.kuam.com/story/30290668/2015/10/18/visitor-numbers-for-japan-fall-flat

Madory, D. (2013, OCTOBER 16). Submarine Cables Add Resilience But Paths Still Matter. Dyn Research. http://research.dyn.com/2013/10/subsea-cables-add-resilience/

Manojlovic, V. (2015, July 21). Extending RIPE Atlas' Reach. Ripe NCC. Retrieved from https://labs.ripe.net/Members/becha/extending-ripe-atlas-reach

Metzger, R. J. (2015). Petition Of Teleguam Holdings, Llc To Deny the Application To Transfer Guam Cellular Licenses. Washington, USA : Federal Communications Commission.

Minges, M., & Stork, C. (2015). Economic and Social Impact of ICT in the Pacific. Sydney, Australia: Pacific Region Infrastructure Facility.

Mitchell, R. (2015, August 21). Internet traffic jam in Asia as submarine cable breaks. APNIC. Retrieved from http://blog.apnic.net/2015/08/21/internet-traffic-jam-in-asia-as-submarine-cable-breaks/

National Telecommunications & Information Administration (n.d). Service Providers Public Notice Submission Choice Phone, LLC. Retrieved from http://www2.ntia.doc.gov/node/422

Nguyen, L. (2014). Unsolicited Offer to University of Guam Telecommunications Proposal. University of Guam Endowment Foundation, Guam.

Norton, W. B. (2011). The Internet peering playbook: connecting to the core of the Internet. DrPeering Press.

Pactel International (n.d). RICS Ku-Band. Retrieved from https://web.archive.org/web/20160411011305/http://www.pactelint.com/products/satellite-internet-products.php?RICS-Ku-Band-1

PCCW Global. (2009, June 24). PCCW Global and Tata Communications jointly strengthen connectivity and reliability in Asia Pacific via the TGN-Intra Asia Cable System. Retrieved from https://www.pccwglobal.com/en/about/newsroom/archive/297-pccw-global-and-tata-communications-jointly-strengthen-connectivity-and-reliability-in-asia-pacific-via-the-tgn-intra-asia-cable-system

picisoc. (2015, July 8). PacINET@NetHui 2015, Auckland, New Zealand. Retrieved from http://www.picisoc.org/2015/07/08/pacinetnethui-2015-auckland-new-zealand/

Pinaroc, J. D. (2015, August 27). Company Proposes Installing Fiber Cable Connections In CNMI. Pacific Islands Report. Retrieved from http://www.pireport.org/articles/2015/08/27/company-proposes-installing-fiber-cable-connections-cnmi

Poppe, Y. (2009a). Partner and participant in Global R&E networking [PowerPoint Presentation]. TATA Communications.

Poppe, Y. (2009b). Connecting emergent R&E networks and applications at lambda speeds [PowerPoint Presentation]. TATA Communications.

Press Release. (2015, September 3). Docomo plans next steps for possible undersea fiber build. Retrieved from http://www.saipantribune.com/index.php/docomo-plans-next-steps-for-possible-undersea-fiber-build/

Pryke, J. (2014, August 28). Pacific Islanders in Australia: where are the Melanesians?. DevPolicy Blog. Retrieved from http://devpolicy.org/pacific-islanders-in-australia-where-are-the-melanesians-20140828/

Reddy, M., & Ghazali, F. (2010). Final Determination on Prices and Access for Southern Cross Capacity and Network. Suva, Fiji: Commerce Commission.

Reddy, M., Mataitin, L., & Shah, K. (2010). Price and Access Determination For Southern Cross Capacity and Network. Suva, Fiji: Commerce Commission.

Rogers, S. (2013, January 28). Borders and boundaries: 16 Google Fusion border files for you to use. Retrieved from https://simonrogers.net/2013/01/28/borders-and-boundaries-16-google-fusion-border-files-for-you-to-use/

Russell, R. (June, 2015). SOCC 2015/01 :Solomon Islands Submarine Cable System –a network of cables from Honiara to Auki, Noro and Sydney. Asian Development Bank, Sydney Australia.

Sanger, D. E., & Schmitt, E. (2015, October 25). Russian Ships Near Data Cables Are Too Close for U.S. Comfort. NY Times. Retrieved from http://www.nytimes.com/2015/10/26/world/europe/russian-presence-near-undersea-cables-concerns-us.html?_r=0

Sea-Me-We3 List Pricings. (2015). [List of pricings based on location].

Senase, J. R. T. (2015, August 8). Palau Misses Chance For High Speed Internet Access Cable. Pacific Islands Report. Retrieved from http://www.pireport.org/articles/2015/08/04/palau-misses-chance-high-speed-internet-access-cable

Shapefiles (n.d). [Maps of various Marine Regions]. Retrieved from http://www.marineregions.org/downloads.php

Snijders, J. (2013). Introduction. NLONG Ring. Retrieved from https://ring.nlnog.net/

Southern Cross Cable Network. (2012). Access & Backhaul. Retrieved from https://www.southerncrosscables.com/#

Starosielski, N., Loyer, E., & Brennan, S. (n.d). Surfacing. Retrieved from http://surfacing.in/

Taitano, C. T. (2016a). Amendment Acknowledgement form RFI 001-2016 Internet Caching Solution Ammendment 1. Barrigada, Guam: Department of Education.

Taitano, C. T. (2016b). Amendment Acknowledgement form RFI 001-2016 Internet Caching Solution Ammendment 2. Barrigada, Guam: Department of Education.

Taitano, C. T. (2016c). Amendment Acknowledgement form RFI 001-2016 Internet Caching Solution Ammendment 2. Barrigada, Guam: Department of Education.

Tatarata, M. (2008). Application for Authority pursuant to Cable Landing License Act 47. Washington, USA: Federal Communications Commission.

The University of the South Pacific. (n.d). MOOC on Climate Change and Pacific Islands. Retrieved from http://www.uspmoocpaccc.org/

Tritt, C. (1992). Joint Application for a License to Land and Operate a High Capacity Digital Submarine Cable Network Between and Among the United States Mainland, the State of Hawaii, the Island of Guam and Japan. Washington, USA: Federal Communications Commission.

Tritt, C. A. (1993). Application for a license to Land and Operate a High Capacity Digital Submarine Cable System Extending Between the Commonwealth of the Northern Mariana Islands and Guam. Washington, USA: Federal Communications Commission.

U.S Department of Education (2010). Nearly $83 Million in Recovery Funds Now Available for Guam to Save Jobs and Drive Reform. Retrieved from http://www.ed.gov/news/press-releases/nearly-83-million-recovery-funds-now-available-guam-save-jobs-and-drive-reform

U.S Securities and Exchange Commission. (1998). Japan - U.S. Cable Network Construction and Maintenance Agreement. Retrieved from https://www.sec.gov/Archives/edgar/data/1278739/000104746904009653/a2131411zex-10_7.htm

United States District Court. (1990, June 12). IT&E OVERSEAS, INC. v. RCA Global Communications, 747 F. Supp. 6 (D.D.C. 1990), Justia US Law. Retrieved from http://law.justia.com/cases/federal/district-courts/FSupp/747/6/1480021/

Unknown. (2015, November 27). Balancing Act – Africa. Issue 805. Retrieved from http://www.balancingact-africa.com/news/issue/telecoms-en/805

Unknown. (2016). DRFortress Peering and connectivity. Retrieved from http://www.drfortress.com/internet-exchange/peering-and-connectivity/

Unknown. (2016). Pacific Community. Retrieved from http://www.spc.int/

Unknown. (2016). Pacific Islands Forum Fisheries Agency (FFA). Retrieved from https://www.ffa.int/

Unknown. (2016). PNG-IXP-Project. Retrieved from http://www.nicta.gov.pg/png-ixp-project

Valemi, R. (2015, December 23). 74m deal. The Fiji Times ONLINE. Retrieved from http://www.fijitimes.com/story.aspx?id=334980.

Verizon (2001). Private Line Service Guam - Saipan Digital Fiber Service.

Verizon (2016). IP Latency Statistics [Statistics of IP Latencies from Verizon Enterprise Solutions]. Retrieved from http://www.verizonenterprise.com/about/network/latency/

Villahermosa, C. A. E. (2015, Septemeber 10). IT&E plan doesn't impress Leepan. Marianas Variety. Retrieved from http://www.mvariety.com/cnmi/cnmi-news/local/79925-it-e-plan-doesn-t-impress-leepan

Villaverde, R. (2011). Practical information about Guam. Retrieved from http://ns.gov.gu/utilities.html

White, J. (2013, January 22). GovGuam's telecom contract still in limbo. The Guam Daily Post. Retrieved http://www.postguam.com/news/local/govguam-s-telecom-contract-still-in-limbo/article_3c5023a2-530d-5ebb-8dfb-e0cb33bf9134.html

Wikipedia. (n.d). Niue: OER Initiatives in Niue. Retrieved from http://poerup.referata.com/wiki/Niue#Internet_in_Niue

Wilson, J. R. (2008). Application for a License to Land and Operate a Private Fibre-Optic Cable System connecting Hawaii, American Somoa and Somoa for the American Somoa-Hawaii Cable. Washington, USA: Federal Communications Commission.