Technical Assistance Consultants’ Report

TA-7787 REG: May 2013

Cook Islands: Report on the Feasibility of an International Submarine Cable System for the Cook Islands

For

The Minister of Telecommunications and the Government of the Cook Islands

May 2013

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<thead>
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<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
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<tr>
<td>ADB-PSOD</td>
<td>ADB Private Sector Operations Department</td>
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<tr>
<td>ADM</td>
<td>Add Drop Multiplexer</td>
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<tr>
<td>ADSL</td>
<td>Asynchronous Digital Subscriber Line</td>
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<td>ASH</td>
<td>American Samoa – Hawaii (Cable System)</td>
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<td>ASN</td>
<td>Alcatel-Lucent Submarine Networks</td>
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<td>BBI</td>
<td>Broadband Internet</td>
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<td>BCCD</td>
<td>Broadband Commission for Digital Development (ITU)</td>
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<td>BMH</td>
<td>Beach Man Hole</td>
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<td>BTS</td>
<td>Base Transceiver Station</td>
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<td>BU</td>
<td>Branching Unit</td>
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<td>Capex</td>
<td>Capital Expenditure</td>
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<td>CIR</td>
<td>Committed Information Rate</td>
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<td>CoC</td>
<td>Chamber of Commerce</td>
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<td>CI</td>
<td>Cook Islands</td>
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<td>CLS</td>
<td>Cable Landing Station</td>
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<td>EDGE</td>
<td>Enhanced Data rates for GSM Evolution</td>
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<td>EIA</td>
<td>Environment Impact Assessment</td>
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<tr>
<td>EIRR</td>
<td>Economic Internal Rate of Return</td>
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<tr>
<td>EMP</td>
<td>Environmental Management Plan</td>
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<td>FIRR</td>
<td>Financial Internal Rate of Return</td>
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<td>FOC</td>
<td>Fibre-Optic Cable</td>
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<td>GNI</td>
<td>Gross National Income</td>
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<td>GSM</td>
<td>Global System for Mobile communications</td>
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<td>GPRS</td>
<td>General Packet Radio Service</td>
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<tr>
<td>HV</td>
<td>High Voltage</td>
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<tr>
<td>ICT</td>
<td>Information and Communications Technology</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical &amp; Electronic Engineers</td>
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<tr>
<td>IFC</td>
<td>International Finance Corporation</td>
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<tr>
<td>IM</td>
<td>Instant Messaging</td>
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<tr>
<td>IRR</td>
<td>Internal Rate of Return</td>
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<tr>
<td>IRU</td>
<td>Indefeasible Right of Use</td>
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<tr>
<td>ISP</td>
<td>Internet Service Provider</td>
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<td>ITU</td>
<td>International Telecommunication Union</td>
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<tr>
<td>JV</td>
<td>Joint Venture</td>
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<tr>
<td>LDC</td>
<td>Less Developed Country</td>
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<tr>
<td>LPA</td>
<td>Landing Party Agreement</td>
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<tr>
<td>LTE</td>
<td>Long Term Evolution (high speed mobile broadband)</td>
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<tr>
<td>MB</td>
<td>Megabyte</td>
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<tr>
<td>MEO</td>
<td>Medium Earth Orbit</td>
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<td>MGW</td>
<td>Media Gateway</td>
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<tr>
<td>MIR</td>
<td>Maximum Information Rate</td>
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<tr>
<td>MLDB</td>
<td>Multilateral Development Bank</td>
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</tbody>
</table>
ms — Millisecond
MSC — Mobile Switching Centre
MSP — Mobile Service Provider
NPV — Net Present Value
NSDP — National Sustainable Development Plan
OADM — Optical Add Drop Multiplexer
OECD — Organisation for Economic Co-operation and Development
Opex — Operating Expenses
OPT — Office des Postes et Télécommunications, French Polynesia
OTT — Over The Top
PFE — Power Feed Equipment
PIFS — Pacific Islands Forum Secretariat
RF — Radiofrequency
RFQ — Request For Quotation
ROM — Rough Order of Magnitude
RTD — Round Trip Delay
RTT — Round Trip Time
SAS — Samoa-American Samoa (Cable System)
SCS — Submarine Cable System
SDH — Synchronous Digital Hierarchy
SLTE — Submarine Line Terminating Equipment
SME — Small to Medium Enterprise
SOCC — Solomon Islands Oceanic Cable Company
SOE — State Owned Enterprise
SPIN — South Pacific Island Network
TA — Technical Assistance
TCI — Telecom Cook Islands
TNZ — Telecom New Zealand
TOR — Terms of Reference
UAS — Universal Access Scheme
UN-ESCAP — United Nations Economic and Social Commission for Asia and the Pacific
VAS — Value Added Services
VSAT — Very Small Aperture (satellite) Terminal
WACC — Weighted Average Cost of Capital
3G/4G — 3rd/4th Generation mobile communications standard

NOTE

In this report, "$" refers to US dollars unless otherwise stated.
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1.0 Executive Summary

The Government of the Cook Islands has recognised that without a reliable supply of lower cost good quality broadband Internet its socio-economic future would be compromised. This feasibility study was commissioned by ADB for and at the request of the Cook Islands to determine if an international submarine cable was feasible particularly when compared with the new reduced cost and low latency (when compared with the existing geostationary satellite) of the O3b satellite solution due to come into service later in 2013. The study identifies what at this time appears to be the best route option for an ultra-high capacity international submarine cable system (SCS) and then compares the medium- to long-term performance and cost benefits of the broadband capacity it would provide with that of O3b.

In February 2013 specialist technical and socio-economic consultants were engaged to complete the study. The consultants travelled to Rarotonga during February and March 2013 and consulted with stakeholders including Government, Telecom Cook Islands, the Cook Islands Chamber of Commerce and other relevant organisations. These meetings confirmed a growing need for more affordable and better quality broadband. An extensive review of relevant existing and proposed policy and regulatory documentation was undertaken. Discussions were also held with potential landing party partners in Samoa and several leading suppliers of submarine cable systems, and budgetary quotations were obtained for the supply of cable systems and landing party services in Tahiti.

1.1 Major Findings

At this time a direct cable from Rarotonga to French Polynesia (Tahiti) represents the most feasible and most likely route for an international submarine cable and so this configuration has been used as the basis for a cost-benefit comparison with O3b’s satellite service due to be introduced in the Cook Islands later this year. The capital cost of this cable is estimated at US$33.6 million.

Note that the selection of this preferred cable route for the analysis does not rule out the possibility of other route options worthy of consideration emerging over the next 12-18 months.

With the important proviso that concessional loan funding can be secured and providing the projected demand is realised there appears to be a sound case for the Cook Islands to invest in and implement an international submarine cable system within the next 5 years.

The primary reasons for this conclusion are:

- An international cable provides considerably greater performance benefits in particular lower latency and greater immunity from natural hazards such as heavy rain, sunspot activity, cyclones and man-made problems such as accidental or malicious radiofrequency (RF) interference.
Assuming the availability of concessional funding and using a 15 year timeframe the financial analysis of an O3b supplied system and the selected cable system shows that the submarine cable provides a higher NPV.

Providing the lower medium to longer term unit cost of capacity on the SCS is passed on by retail service providers the savings achieved will deliver the socio-economic benefit of an increase in consumer surplus.

Meanwhile in the short to medium term O3b should bring to the Cook Islands the anticipated benefits of more plentiful capacity, lower price and better quality broadband that is needed to meet increasing demand for affordable broadband Internet and the surge in growth anticipated from the introduction of 3G mobile services later this year. If an international submarine cable was to be introduced towards the end of Telecom Cook Island’s 5 year contract with O3b, those satellite services could then be very usefully redeployed under a new contract to provide essential national backhaul and international diversity capacity.

1.2 Next Steps

In the event that the Cook Islands Government decides to proceed with the plans for an international submarine cable a ‘road map’ has been proposed for consideration. It calls for an early engagement with potential lenders to the SCS project and for the establishment of ongoing high level dialogue with French Polynesia, Samoa and possibly other countries or investors in cable systems so that an awareness can be maintained of any changes to existing cable options as well as future developments.

It is also important that over the next 18 months following the introduction of both 3G mobile services and the O3b service that the level of demand is monitored to confirm it is achieving the growth that has been projected to justify the introduction of a cable system.

Finally it is suggested that a coherent and appropriate regulatory framework for telecommunications will, as is already planned, need to be implemented and decisions made concerning the future ownership and structure of Telecom Cook Islands in order to minimise the level of investment risk that providers of funding for a SCS might otherwise perceive.

2.0 Introduction

2.1 Background

In September 2010 the Broadband Commission for Digital Development\(^1\) presented to the ITU and UNESCO a landmark report titled “A Leadership Imperative – The Future Built on Broadband”. The report states that:

\(^1\) [http://www.broadbandcommission.org/#about](http://www.broadbandcommission.org/#about)
“While strong market demand in the form of mobile telephony and the internet have since driven the explosion of worldwide ICT diffusion even in the world’s poorest countries, we believe we have once again arrived at a crossroads in the evolution of the global digital highway, with broadband as the next great leap forward.”

The Government of the Cook Islands recognises that a reliable supply of affordable good quality broadband Internet – now widely regarded globally as essential infrastructure, similar to electricity and water distribution networks – is crucial to the economic growth of the country and the improvement of its people’s lives. In the case of relatively isolated Pacific nations such as the Cook Islands the major hurdle to achieving such a supply has been a total dependency on expensive geostationary satellite capacity.

Following a request in 2012 by the Cook Islands Government, the Asian Development Bank in January 2013 engaged two specialist consultants under a Technical Assistance program as part of its Pacific Regional Information and Communications Technology Connectivity Project to undertake a study on the feasibility of an international submarine cable system for the Cook Islands.

2.2 Scope

The scope of the telecommunications study, as stated in the collective Terms of Reference for both consultants, was primarily to investigate the medium-to-long-term technical, financial, economic and institutional feasibility of an international submarine cable for the Cook Islands in comparison with alternative satellite-based solutions. While both consultants have worked in close liaison with each other, Hugh McGarry was engaged to focus primarily on the technical, regulatory and institutional aspects of the study, with Noelle Jones undertaking mainly the financial and economic analysis.

The outputs of the telecommunications study as described were to comprise broadly of:

- Preparation of budgetary cost estimates for several alternative SCS configurations.
- A telecommunications sector analysis including an assessment of the regulatory environment
- A cost/performance comparison between the potential SCS systems and satellite-based alternatives in financial and economic terms.
- An assessment of how an SCS could contribute to national priorities as identified in the National Sustainable Development Plan, the country’s poverty reduction strategy and telecommunications sector analysis.
- The identification and analysis of likely economic uncertainties that could affect the project’s viability, and undertake risk and sensitivity analysis with respect to the FIRR and EIRR.
- Assess institutional formation options for a possible cable company.
- Assist key stakeholders in identifying and exploring various potential private and public sector financing models,
• Assess the justification if any for a sovereign component in the financing structure of the investment.

2.3 Consultancy Approach

ADB’s Technical Assistance program for this consultancy commenced in January 2013. The technical consultant while attending the annual Pacific Telecommunications Council in Hawaii in January 2013 met with O3b in order to gain a fuller understanding of the technical and commercial aspects of the MEO satellite services that have been contracted for delivery to Telecom Cook Islands in the second half of 2013. While in Hawaii meetings were also held with the Office of Posts and Telecommunications (OPT), French Polynesia and the CEO of Blue Sky Samoa since these two countries are possible landing points for any future Cook Islands international submarine cable system. Meetings were also held with SCS suppliers Alcatel Submarine Networks and Huawei. Both suppliers agreed to assist the study by providing budgetary capital costs (ROM) for a short-list of possible cable configurations.

The consultants travelled separately to the Cook Islands in mid-February and early March for meetings with stakeholders as part of the data gathering exercise. Further discussions were held with Pua Hunter of the Cook Islands Government, TCI and O3b during the APT/ITU Pacific Forum Conference in Samoa at the end of April. A final visit was made to the Cook Islands in May to share the draft study with the Cook Islands Government prior to its finalisation.

The work has been carried out in Rarotonga and at the consultants’ respective home-offices.

A Desk Review was performed, encompassing documents considered relevant to the project, including:

• Cook Islands Telecommunications Act of 1989
• Cook Islands Telecommunications Act Amendment 1997
• Cook Islands Telecommunication Industry Principles (January 2013)
• National Sustainable Development Plan (2011-2015)
• Cook Islands Economic Prosperity – Updating our Way Forward (February 2013)
• Cook Islands National Health Strategy (2012-2016)
• Cook Islands Ministry of Health ICT Policy & Procedures 2011
• Cook Islands Education Master Plan (2008 – 2023)
• Cook Islands Banking Review 2012
• Cook Islands Population Census Report 2011
• Cook Islands Budget Half-yearly Update 2013
• The Environment Act 2003
• Environmental Management Plan (EMP) for Marine Projects
• Environment Impact Assessment (EIA) for Arorangi Cruise Ship Tender Landing Jetty
• Cook Islands Seabed Minerals Act 2009
• Cook Islands Seabed Minerals Policy 2010
2.3.1 Stakeholder Meetings

Introductory and information gathering meetings were held with the Cook Islands Government Ministries and Departments and private sector entities who were likely to have an interest in the future of broadband Internet availability. The purpose was to brief stakeholders on the objectives of the study and to understand any particular existing or future broadband needs that they may have. Those met included:

- Hon. Mark Brown, Minister of Telecommunications
- Ms Elizabeth Iro, Secretary of Health
- Mr Tofinga Aisake, ICT Manager, Ministry of Health
- Mr Richard Neves, Secretary of Finance and Economic Management
- Mr Enua Pakitoa, Senior Statistician, Ministry of Finance & Economic Management
- Ms Amelia Ngatokorua, Senior Statistician, Ministry of Finance & Economic Management
- Mr Rob Matheson, Director ICT, Ministry of Education
- Mr Mac Mokoroa, Acting Secretary, Ministry of Infrastructure and Planning
- Ms Elizabeth Koteka, Chief of Staff, Office of the Prime Minister
- Ms Pua Hunter, Director ICT, Office of the Prime Minister
- Mr Nooroa Maui, Manager Technical Services, The Airport Authority
- Mr Halatoa Fua, CEO, The Tourism Commission
- Mr Geoffrey Tama, ICT Systems Co-ordinator, The Tourism Commission
- Mr Jake Numanga, Research and Statistics Officer, The Tourism Commission
- Mr Teina Rongo PhD., Coral Reef Ecologist
- Mr Jules Maher, CEO, Telecom Cook Islands
- Ms Teresa Manarangi-Trott, President, The Cook Islands Chamber of Commerce
- Mr Rod Dixon, Director, The University of the South Pacific Cook Islands
- Mr Fereti Atalifo, The University of the South Pacific
- Mr William Framhein, Director, Mervin Communications
- Mr Ronald Patia, Acting CEO, Bank of the Cook Islands
- Mr Angarei Kavana, Westpac
- Ms Maureen Hilyard, Cook Islands Internet Action Group
- Mr Brian Mason, Attorney
- Ms Vanessa Jenner, Cook Islands Donor Co-ordination Office, MOF & EM
- Mr Stuart Davies, Asia-Pacific Telecommunity (by Skype)
2.4 Limitations of the Study

The two main limitations of the study which prevent it from being as definitive as would be ideal are:

- The difficulty of forecasting future demand for capacity in an environment undergoing significant evolution of networks, devices and applications coupled with increasing affordability for a market with a relatively modest user base.
- The difficulty in comparing empirical reliability and performance characteristics of a preferred submarine cable option and O3b’s MEO satellite system when the latter will not enter service until the 4th quarter of this year.

2.5 Structure of the Report

Following the Executive Summary and this Introduction, the Telecommunications Sector Profile (Section 3) describes the state of telecommunications services and infrastructure development in the Cook Island. An assessment of the Cook Islands regulatory landscape follows in Section 4.

Section 5 examines the most feasible options for international submarine cable connectivity. Sections 6, 7 and 8 compare in terms of performance and medium- to long-term investment value the most favoured of the SCS options with O3b’s MEO satellite service; due to be activated in the 3rd quarter of 2013.

Section 9 examines the institutional arrangements that could be adopted to own and operate a submarine cable as well as funding options for the venture.

Section 10 contains the conditional conclusions and a recommended road map for consideration by the Cook Islands Government.

3.0 Cook Islands Telecommunications Sector Profile

3.1 Introduction

This section provides an overview of the prevailing telecommunication landscape in the Cook Islands in the context of the study into future international broadband options. It focuses on those aspects of the sector which impact the Cook Islands’ future capacity and in particular broadband Internet in terms of affordability and quality.

The Cook Islands market base consists of a resident population of almost 15,000² spread over the 12 populated islands of the 15 islands in total. Almost three quarters (74%) of the population resides on Rarotonga. Tourism is estimated to account for around 65% of the Cook Islands’ GDP³. The country receives a growing number of

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² Cook Islands Census 2011.
³ http://www.mfat.govt.nz/Countries/Pacific/Cook-Islands.php
international tourists each year (121,600 visitors in 2012\(^4\)) which provides an increasing source of demand for affordable good quality telecommunications services, and particularly broadband Internet to support social media and video applications.

The relatively benign topology of the individual islands that make up the Cook Islands has facilitated high penetration levels of fixed and mobile services when compared to many of its more populated neighbours. This provides a solid national user platform on which to deliver affordable broadband Internet services.

3.2 Existing Suppliers

3.2.1 Telecom Cook Islands

3.2.1.1 General

Established in 1991 Telecom Cook Islands (TCI) is by virtue of a joint-venture agreement between the Cook Islands Government and Telecom New Zealand the monopoly provider of all telecommunications services in the Cook Islands. Prior to 1991 international communications had been provided for some years by Cable & Wireless.

Initially the ownership structure of TCI was 60% Cook Islands Government and 40% Telecom New Zealand (TNZ). In July 1997 TNZ acquired a further 20% of the company for NZ$3 million making it the majority shareholder and implying a value for TCI at that time of NZ$15 million. In the previous financial year TCI reported a gross revenue of NZ$12 million and a profit of NZ$1.3 million.\(^5\)

TCI also remains the provider of Postal Services, Marine Radio communications and Directory Services.

3.2.1.2 Services Offered

As at early 2013, TCI delivers:

- just under 11,000 mobile subscriptions, including both pre- and post-paid plans. Full international roaming is available.
- mobile data services (EDGE/2.5G) – TCI’s mobile network is expected to be upgraded to 3G technology in late 2013 or early 2014
- around 7600-7700 fixed lines providing local and international fixed line telephony
- approximately 2500 fixed broadband (ADSL) services
- domestic and international leased line services are available to business customers
- around 160 Wi-Fi Hotspots (as at February 2013). Service is offered on pre-paid basis although existing Internet (post-paid) subscribers can also access the service. TCI will also provide a Wi-Fi Hotspot in

\(^4\) Information supplied by the Cook Islands Tourism Corporation.

\(^5\) TNZ Media Release Archive for July 1997.
the home for a small monthly rental which families can also use on a pre-paid basis. A fixed telephone line in the home is a pre-requisite for this service.

3.2.1.3 Pricing

Its monopoly position notwithstanding there is a prevailing view that in recent years TCI has worked diligently to reduce tariffs as well as increasing the penetration of services. A review by independent consultants Network Strategies in late 2012 reported that TCI’s tariffs compared well with many other Pacific nations. The introduction of 3G mobile services is somewhat late however compared to other countries particularly given the importance of mobile data to the increased availability and uptake of broadband Internet.

**Table 1:** Monthly spend on broadband Internet access as a proportion of average monthly income [Source: Network Strategies, November 2012]

<table>
<thead>
<tr>
<th>Country</th>
<th>Low-level use (2GB per month)</th>
<th>High-level use (6GB per month)</th>
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<tbody>
<tr>
<td>Cook Islands</td>
<td>4.1%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Federated States of Micrones (FSM)</td>
<td>13.9%</td>
<td>13.9%</td>
</tr>
<tr>
<td>Fiji</td>
<td>5.3%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Kiribati</td>
<td>42.2%</td>
<td>98.4%</td>
</tr>
<tr>
<td>Niue</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Palau</td>
<td>27.5%</td>
<td>27.5%</td>
</tr>
<tr>
<td>Papua New Guinea (PNG)</td>
<td>150.9%</td>
<td>416.5%</td>
</tr>
<tr>
<td>Republic of the Marshall Islands (RMI)</td>
<td>18.9%</td>
<td>18.9%</td>
</tr>
<tr>
<td>Samoa</td>
<td>14.5%</td>
<td>36.5%</td>
</tr>
<tr>
<td>Solomon Islands</td>
<td>123.8%</td>
<td>204.9%</td>
</tr>
<tr>
<td>Tonga</td>
<td>19.0%</td>
<td>35.4%</td>
</tr>
<tr>
<td>Vanuatu</td>
<td>24.6%</td>
<td>24.6%</td>
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3.2.2 Other Suppliers

Since any introduction or permitting of competition in the telecoms sector by the Cook Islands Government would breach the terms of the existing Joint Venture (JV) agreement with TNZ there are currently no infrastructure-based competitors, only resellers of TCI services.

3.3 TCI Network Infrastructure

3.3.1 Mobile & Mobile Data

GSM 900 was introduced in 2003 and nine of the 12 populated islands have mobile coverage. Mobile data using GPRS/Edge (2.5G) technology delivering up to a maximum nominal speed of 144 kbps has been offered since 2007. TCI is understood to be planning to introduce 3G services in late 2013 or early 2014.
3.3.2 Fixed Line and Broadband Internet

All populated islands in the Cook Islands have fixed line service and broadband Internet over ADSL. Speeds of up to 3 Mbps and 512 kbps are available on Rarotonga and the outer islands respectively, with the achieved speed depending on distance from the nearest exchange.

3.3.3 Wi-Fi Hotspots

TCI’s 160 Wi-Fi Hotspots are located throughout Rarotonga and Aitutaki. Connected via ADSL-equipped lines they deliver similar speeds and customers may select from a variety of data usage plans.

3.3.4 National Backhaul Networks

In order to link its mobile base stations and fixed line network on Rarotonga with the main switching centre and international gateway in Avarua TCI uses microwave links as well as a self-healing fibre-optic link that encircles the island.

On the outer islands the mobile base stations rely on satellite links employing VSAT technology to connect to Avarua.

3.3.5 International Networks

At the time of writing TCI is totally reliant on geostationary satellite capacity through its Avarua main earth station for international voice and data connectivity. TCI uses two diverse satellite links and currently employs about 90 Mbps of capacity of which 7 Mbps is deployed for national links to the outer islands.

The inherent disadvantages of using geostationary satellite technology for international communications, rather than broadcasting (an application for which satellites are ideally suited) are higher recurring capacity leasing costs and lower performance when compared to fibre-optic submarine cables.

The reliance on satellite also for outer island links further impairs the quality of international voice and Internet services for those users by necessitating a ‘double-hop’ or the use of two discrete satellite links for each call or session. This doubles the latency or delay that would otherwise be incurred.

In recognition of the limitations of geostationary satellite capacity TCI four years ago gave consideration to a submarine cable system for its international connectivity. However at that time the system was rejected by the company due to the high initial capital cost for a relatively small addressable market.

Also at about that time O3b announced that it would be launching its Medium Earth Orbit (MEO) satellite system which it was claimed would reduce the cost and inherent latency (round trip delay) of service by two-thirds of that of the existing geostationary systems. The original launch date of the O3b system was to be Q4 2010 but is now scheduled for Q4 2013. TCI was one of O3b’s first Pacific customers to contract for the service and has committed to a service period of five years from first availability.
3.4 Other Networks

By arrangement with TCI the University of the South Pacific and several commercial banks are allowed to connect directly by satellite to their own regional private networks.

3.5 Government Use of ICT

The ITU Broadband Commission for Development in a 2010 report asked the leading question “Are governments fully aware of the enormous potential of broadband to deliver services to their citizens?”

The Cook Islands Government does not have a dedicated private network. As one of TCI’s largest customers it has negotiated terms more favourable than those of standard retail services. These terms encompass the services of most Government departments however purchasing and billing is not yet centralised.

4.0 The ICT Regulatory Environment

4.1 Background

The Telecommunications Act of 1989, amended in 1992, governs telecoms in the Cook Islands. It together with the JV between TNZ and the Government enshrines TCI as the sole provider of telecoms services in the Cook Islands by prohibiting any other company or person from operating a network.

The Cook Islands has no separate legislation on consumer protection. The Control of Prices Act of 1996 established a Price Tribunal with responsibility to address complaints addressed to the tribunal. It is not known if the Tribunal has ever been called upon to investigate telecommunications services.

As market liberalisation and regulatory reform of the global telecommunications industry has moved forward elsewhere there has been a growing dissatisfaction in the Cook Islands with this monopoly arrangement, resulting in increasingly loud calls for reform from the business community and some areas of Government. In 1996 at the Government’s request, and prior to the expiry of the exclusivity provisions of TCI’s then current license, the Pacific Island Forum Secretariat completed a report on options and strategies for development of the telecoms sector in the Cook Islands.

That report in highlighting issues such as high prevailing tariffs called for “...immediate and drastic remedial action” and recommended a set of actions to be followed over the following 12-18 months. These recommendations included an immediate tariff review, amendments to the Telecom Bill, and the establishment of a Regulator to facilitate the introduction of competition to the sector. The report also recommended that over the medium term the Government should divest itself of all or most of its direct shares in TCI.

6 Cook Islands Telecommunications Strategy 2007 - by John Budden, Economic Infrastructure Advisor. PIFS
Up until fairly recently there were few indications that the recommendations were being actively pursued by the Government however at the time of writing there is evidence of a new determination to introduce the necessary reforms.

4.2 Going Forward

The National Sustainable Development Plan 2011-2015 clearly identified telecommunications and regulatory reform as being of critical importance to the achievement of its national objectives. The NSDP states that:

“We will commit to strengthening our telecommunications regulatory framework and develop and implement policies and regulations that will result in improved telecommunications infrastructure and services. Changes to our telecommunications regulatory framework will be complemented by the most appropriate institutional arrangements to monitor telecommunications development and compliance, carry out regulatory responsibilities, drive policy development, and identify areas for capacity building to improve efficiencies in other productive sectors.”

In February of this year the Telecommunications Minister, the Hon Mark Brown, released the Cook Islands ‘Telecommunication Industry Principles’, which outlines the government’s vision for an improved telecommunication sector. The Minister stated that “The government clearly believes that the provision of world class telecommunications infrastructure and information is the key to rapid economic and social development of the country.” It is understood that that the principles are to be debated in Parliament with a view that they would be then be passed into law during 2013.

The document calls for reduced barriers to competition in the market through actions such as:

- The establishment of an independent telecommunications regulator and the introduction of a less prescriptive legislative regime.
- The establishment of a commission to oversee the licensing of spectrum and the issuance of service and network licenses as well as the management of equipment type approvals.

4.3 Telecommunications Regulatory Reform and Investment

“Governments should form a regulatory framework that promotes confidence and trust.”

In considering the future possibility of an international submarine cable for the Cook Islands the importance of a well-regulated telecommunications sector cannot be over-emphasised. Given the large capital sums required to fund an SCS, investors and lenders will want to see evidence of such. Lenders such as MLDBs will need to see evidence of regulations that can ensure that the benefits of the investment flow through to the consumer and business. Even purely commercial lenders and

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7 Budden Report
investors will view the absence of clear policy and regulation as heightening their overall risk.

5.0 Analysis of International Submarine Cable Route Options

5.1 Geography

The Cook Islands are the result of volcanic activity and coral growth in the centre of the South Pacific Basin. The islands of Rarotonga, Mangaia, Atiu, Mauke, Mitiaro and Aitutaki are formed from the peaks of extinct volcanoes. The islands of Manuae, Palmerston, Penrhyn, Manihiki, Rakahanga, Pukapuka, and Suwarrow however are atolls formed on coral reefs around a lagoon above several submerged volcanoes.

The islands rise steeply from the ocean floor about 4,500 metres below. The Cook Islands by virtue of their location in deep waters and away from areas with high levels of tectonic activity possess a relatively benign environment for a submarine cable.

Figure 1: Relief map of seabed in the region [Source: Dr Malcolm Buck, Vulcanologist]

5.2 Background

The principal objective of an international cable from the Cook Islands would be to provide connection to the global Internet. In mid-2009 Hibbard Consulting at the request of TCI carried out a brief initial assessment of SCS routes for the Cook Islands and identified the following three most likely options:

- a cable to French Polynesia
• a repeatered cable to Samoa (Pago Pago)
• a Branching Unit and spur cable on the planned SPIN cable system.

The conclusion at that time was that the best option would be to connect to the planned SPIN cable which was to pass some 600 km to the north of the Cook Islands, the second choice being a submarine cable direct to Tahiti. At the time of that assessment OPT French Polynesia had announced the construction of an SCS from Tahiti to Hawaii (Honotua) upon which the Cook Islands would depend in order to gain access to the global Internet at Hawaii. A cable to Pago Pago in American Samoa was considered less attractive at the time primarily due to the additional distance as well as the shorter life and lower capacity of the ASH cable from Pago Pago to Hawaii when compared with that of the Tahiti option.

5.3 Methodology & Design Issues

The criteria used for selecting a short list of SCS options for closer evaluation were, as in the case of the 2009 assessment, primarily distance or cable length (hence cost) and the likely availability of plentiful and affordable onward connectivity at the other or ‘B End’ of the cable. To facilitate a like-with-like comparison of cables and satellite services it has been assumed that any future SCS would land on Rarotonga and probably be ‘point-to-point’. Attempting to include the Northern and Southern island groups with their relatively small populations would without doubt make an SCS unaffordable. If however a particular configuration may also facilitate the connection of another island or islands without materially increasing the cost this is noted as an additional benefit.

It should be emphasised that the final and exact route and landing point of any submarine cable will be subject to a full ‘desktop’ study followed by a marine survey of the entire route. That route would take into account any activities such as sea-bed exploration or mining. A full Environment Impact Study (EIS) would also be required by the project. The main objective at this point is to arrive at a budgetary cost for an SCS using a route considered optimal and then to compare that with the longer term cost-benefits of the satellite alternatives.

The costs of each route option have been estimated using well-understood and established current market costs for the major capital and operating cost components. In addition a Rough Order of Magnitude (ROM) or budgetary quotation for the supply of each of the three shortlisted SCS options was obtained from ASN the long-established SCS supplier. This was used to validate and refine where necessary the budgetary capital costs and these estimates have then been used as the basis for establishing a preferred cable route.

5.3.1 Design Assumptions

It has been assumed for the study that only newly manufactured cable will be employed for the Cook Islands and not ‘recovered’ cable. The last five years have seen some successful use of ‘recovered’ cable for new installations. In those cases a retired SCS was recovered from the seabed and laid in a new location with considerable capital cost savings. In most cases however the terminating location of one end of the recovered cable was unchanged which reduced cost and complexity.
It was felt that for this exercise there are too many unknown variables and risks to justify consideration of using recovered cable, including:

- the price that one would need to pay the owners of the retired cable
- the cost of recovering the cable to be re-used
- the increased risk of damage to the cable during the recovery operation
- the likely lack of supplier warranty
- a possible shortage of spares
- the shortened life of the system
- a significantly lower system capacity when compared to that of a new cable.

For the purposes of the estimates the following main technical assumptions have been made with regard to a new SCS.

- $1 \times$ Fibre Pair per cable
- Dual-End Power Feed Equipment.
- $32 \times 40$ Gbps wavelength capacity ($1,280$ Gbps).
- $1 \times 40$ Gbps initial ‘lit’ capacity
- Multiplex equipment sufficient only for initial needs.

These are what would be a typical minimum specification for a SCS and would more than meet the future capacity needs of the Cook Islands.

5.3.2 SCS Operating Costs

The most significant operating expense for cable systems is for “marine maintenance”. This cost is effectively an insurance policy to ensure that in the event of a fault in the submerged cable a specialist cable ship will be immediately available to make repairs. Historically the incidence of faults in the deeper areas of the Pacific has been low and so the cost of marine maintenance has seemed high.

The most common arrangement is a situation where the cable repair is covered by an agreement with a South Pacific-based provider for immediate (normally within about ten days) attendance. A considerably lower cost alternative would be to negotiate an arrangement where the repair ship is drawn from a pool. This provides less immediacy for securing a repair ship and may result in the cable being out of service for a 4-5 week period instead of 10 days. Both FSM and French Polynesia are understood to have such an arrangement in place. In order to be conservative we have assumed the higher cost alternative in the business case.

We also need to attribute operational costs to the cable landing station. These include land rentals, power and staffing. Given that the routine maintenance requirement for a cable system terminal is about 30 minutes per day and or just 16 hours a month, it is reasonable to expect that requisite technical and perhaps accounting staff would be contracted on a part-time or outsourced basis and we have assumed here that this will be the case.

A variable operating cost – driven by utilised capacity – will be the cost of connectivity to the global Internet at the respective distant or ‘B Ends’ of the cables.
That connectivity can be achieved in one of two ways. In the case of the options under consideration one could lease connectivity at the B End; for example in the case of a cable to Tahiti with onward connection to Hawaii where one could purchase what is known as Tier 1 IP Transit. One could also consider purchasing IP Transit, if commercially available, at the B End, perhaps from the Landing Party. The amount of capacity required in either case will depend on and vary in proportion to prevailing traffic volumes.

5.4 Analysis

5.4.1 Regional Changes since the 2009 Assessment

Since the Assessment undertaken by TCI the following main changes to the submarine cable ‘landscape’ have taken place:

- Tahiti’s Honotua cable system to Hawaii came into service in 2010 along with its domestic cable system.
- American Samoa’s ASH and SAS cable systems to Hawaii and Samoa respectively were commissioned in 2009.
- The proposed SPIN cable which would have passed about 600 kms to the north of the Cook Islands did not materialise due to lack of funding.
- Another proposed trans-Pacific cable, Pacific Fibre, did not proceed past the funding stage and collapsed in mid-2012.
- A Tonga-Fiji cable is due for completion by mid-2013.
- A Vanuatu-Fiji cable has been ordered and is due to become operational in early 2014.
- The Southern Cross cable system has been upgraded several times to increase capacity and the most recent of these will deliver total system capacity of 2.6 Tbps by mid-2013.
- The Hawaiki cable system was announced in mid-2012, and is planned to run from New Zealand to the US west coast with a spur to Hawaii.
- In January of this year a new trans-Pacific cable ‘APX-East’ was announced which is planned to run from Australia to the US west coast with spurs into New Zealand and Hawaii and possibly other Pacific countries along the route.

5.4.2 Cable Landing Sites on Rarotonga

A preliminary ‘desktop study’ undertaken as part of the ill-fated SPIN project had originally selected Avarua on Rarotonga as the landing point for the spur cable. This landing point selection was subsequently changed to Aroa on the south west of the island, on the basis of local advice that Avarua with its northerly aspect was more exposed to cyclones. For the purposes of deriving these budgetary costs Aroa has also been used here as a theoretical landing point for any SCS. As stated earlier this would need to be confirmed before implementation by a full and detailed geophysical sea and land survey however any change of location would not have a material impact on the capital cost of the physical cable.
5.4.3 International Routes Shortlisted

The three most promising SCS route options for the Cook Islands remain almost the same as those arrived at in the 2009 assessment, namely (the order does not denote preference):

- a direct cable to Samoa
- a direct cable to French Polynesia
- a spur and Branching Unit on any new cable passing close to the Cook Islands.

What have changed however with regard to the previously short-listed routes are the existing and possibly future circumstances surrounding each of these routes which affect the relative attractiveness of each option. These circumstances are explored in the analysis below.

All other possible routes to significant submarine cable hubs such as to Fiji or Hawaii have, as previously, eliminated themselves on the basis of the much greater distances and resultant cost.
5.4.4 Rarotonga-Samoa Repeatered Cable (1,631kms)

**Figure 3:** Rarotonga-Samoa Cable [Source: ASN]

5.4.4.1 Samoa Landing Point and Landing Party Arrangement

If this route was selected a landing at Apia in Samoa is proposed as it would be preferable to landing at Pago Pago in American Samoa mainly due to the steepness of the approaches and the more stringent, protracted and costly process of obtaining a permit to land a cable in a US territory.

5.4.4.2 Onwards Connectivity

Samoa is today connected to Hawaii via the ASH cable which was commissioned in 2009 and is now owned and operated by BlueSky, one of the main carriers in American Samoa and Samoa. Although the ASH cable does land and terminate at Pago Pago this would not restrict Cook Islands access to that capacity since Apia and Pago Pago are connected by a short unrepeatered cable with an estimated system capacity of 3.2 Tbps. Since this short cable is unrepeatered and can be upgraded if needed it has virtually unlimited capacity.

The most immediate constraint on capacity would be the fact that the ASH cable has a system capacity of only 1 Gbps; and as it employs an older recovered cable it is not upgradeable without changing all repeaters on the system. At this time ASH is estimated to be close to 60-70% full; by the time a cable from the Cook Islands was to land at Samoa, which would be at the very earliest three years from now, that capacity would likely be exhausted. American Samoa and Samoa are well aware of this constraint and are both actively and together examining options for a new cable system.

The Samoan Government is currently considering a direct cable to Fiji.
BlueSky, the dominant operator in both Samoas and the owner of the ASH and SAS cable systems, is also considering future options for a second cable. BlueSky is understood to be interested in the possibility of connecting by a spur and branching unit to the proposed APX-East system which was announced in January 2013 and is projected to be in service by mid 2015.

The planned trans-Pacific Hawaiki cable system would also pass relatively close to the Samoas. It is widely believed that only one additional trans-Pacific system can be justified at this time and the prevailing market view is that there is much greater chance of success with the APX system than the Hawaiki project. In any event it is very likely that within the next two to three years the Samoas will have the option of connecting to a new passing trans-Pacific cable which in turn would assure the Cook Islands of an ample supply of onward connectivity to the global Internet. This could be achieved by either purchasing IP Transit at Samoa or leasing capacity from a Samoan cable operator. For the purposes of estimating the connectivity costs of this option it has been assumed that IP Transit would be purchasable at Samoa at a rate similar to that available in Fiji on Southern Cross and that the price should decrease annually by 10-15%.

5.4.4.3 Costs

The capital cost for an SCS to Samoa is estimated at US$35.9 million and the first year operating cost at US$1.5 million. A breakdown of the major elements of these costs is contained in the Financial & Economic Comparison (Section 8.0).

5.4.5 Rarotonga-Tahiti Repeatered (1,631 kms)

**Figure 4:** Rarotonga-Tahiti Cable [Source: ASN]
5.4.5.1 Tahiti Landing Point and Landing Party Arrangements

Following initial discussions with OPT (the owners and operators of the Honotua SCS) we were advised that the existing Papenoo cable landing station (CLS) would not be able to accommodate a new cable from the Cook Islands as well as a second international SCS of its own which is currently being considered. OPT has proposed instead landing the cable from Rarotonga at Papeari on the South West of Tahiti Island (Figure 5). There would then be about 6 km of backhaul cable to an OPT Building at Taravao within which a new CLS facility would be constructed. We are advised that there is ample SDH and Ethernet connectivity at the Taravao link to the Honotua cable at Papenoo on the northern side of the island.

Figure 5: Rarotonga-Tahiti Cable – Backhaul from LP to CLS [Source: OPT, Tahiti, French Polynesia]

5.4.5.2 Onwards Connectivity

Tahiti is connected to Hawaii by OPT’s Honotua cable which was only completed in 2010 and so has a long system life remaining. It has a current system capacity of 640 Gbps of which only 20 Gbps is actually activated. The cable is capable of being upgraded to 2.5 Tbps and possibly even double that figure if the system – as is currently believed – proves capable of supporting 100 Gbps wavelengths. In summary it has an abundance of capacity and more than enough to meet the needs of French Polynesia plus the Cook Islands’ onward connectivity requirements for any foreseeable future.

In order to access the global Internet an amount of capacity dictated by the Cook Islands’ actual traffic needs will need to be purchased on Honotua to reach Hawaii where IP Transit can be purchased for an estimated cost of US$15 per Mbps. The cost of such onward connectivity as in the case of Samoa can be expected to decrease by 5–10% annually.
OPT is also actively examining the feasibility of building a second SCS from Tahiti to provide diversity for its growing needs. Among the more favoured routes is a cable to Fiji or a cable to Samoa. The latter – which would be the shorter and less expensive of the two – would only make sense if Samoa was to connect to APX East Fiji.

5.4.5.3 Costs

The capital cost of a cable to Tahiti is estimated at US$33.6 million and the first year operating costs at $1.3 million. A breakdown of the major elements of these costs is contained in the Financial & Economic Comparison Section 6.3.

5.4.6 Spur and Branching Unit on New Third Party Cable

5.4.6.1 Location of BU

With the demise of the SPIN proposal the Cook Islands’ most promising option for a BU and spur connection to another passing cable would be one running from Tahiti to Samoa or Fiji, both of which are being actively considered by OPT at the time of writing. Either of these cables would pass in an east-west direction relatively close to the north of the Cook Islands.

The path of such a cable from Tahiti to Samoa or Fiji has been estimated to pass about 500 kms to the north of Aitutaki. It has been further estimated that changing the route of such a cable to bring its path further south could bring it within about 30 kms of Aitutaki with a relatively small increase to the overall length of the main cable. This would mean that the total cable distance comprising the BU-Aitutaki and Aitutaki-Rarotonga sections would be less than with other options but also that they could be completely unrepeatered and thus reduce the capital costs of cable significantly for these sections.

**Figure 6:** Branching Unit and Spur Configuration [Source: ASN]

An additional significant benefit, given the plans to further develop Aitutaki as a major tourist destination, would be that this option would deliver a future-proof supply of high-quality broadband capacity to the island.
This arrangement would clearly require the agreement and cooperation of the owners of the cable to which the Cook Islands would connect. It would also only be cost-effective to have such a BU and spur installed at the same time as the main trunk. If the hypothetical trunk cable was to be designed and installed before the Cook Islands was in a position to commit to the whole BU and spur system, the Cook Islands could purchase what is known as a “sleeping BU” on the main trunk. This calls for a BU with a short stub cable to be purchased by the Cook Islands and installed with the main cable for later use. A BU and stub would cost about US$2.3 million. In such a case however the cost of laying the cable and installing terminal equipment would be much higher than if all such work was undertaken at the same time and likely negate the cost attractiveness of the BU option.

5.4.6.2 Connectivity Arrangements

Having connected to the cable by means of a BU one would also need to purchase capacity on the main trunk cable. This will normally be in the form of an Indefeasible Right of Use (IRU). An IRU is an agreement which provides the indefeasible right to use a fixed amount of capacity on a submarine cable for a defined period of time, typically the cable life span, which in this case would be 25 years. An IRU provides the option of not having to commit to the minimum investment level required in the main submarine cable in order to benefit from international connectivity. It is normally payable in advance of construction and in full.

Since the Cook Islands would be connecting at the optical level the minimum unit of IRU capacity of one wavelength would provide a system capacity of $32 \times 40$ Gbps. This should more than meet any future requirements of the Cook Islands. The price of the IRU on the trunk cable to provide capacity to either Samoa or Tahiti is however difficult to estimate since such an envisaged trunk cable (e.g. Tahiti-Samoa) would not be a high traffic route but mainly serve for mutual restoration purposes. For this exercise a best estimate of US$10 million has been made for the IRU. This represents about 30% of the capital cost and it is possible that the cost may be higher depending on the disposition of the owners of the trunk cable.

It has been assumed that IP Transit would be purchasable at Samoa at a rate similar to that available in Fiji on Southern Cross.

5.4.6.3 Costs

The capital cost of the BU and spur to Aitutaki plus the Aitutaki-Rarotonga option as described above is estimated at approximately US$33.7 million and the first year operating expenses at about US$1.0 million.

The high cost of an IRU has the effect of making the capital cost of this option very similar to a direct cable to Haiti.

A breakdown of the major elements of these costs is contained in the Financial & Economic Comparison Section 8.0.
5.5 Summary of International Cable Options

5.5.1 Cost Summary of Options

The economic analysis found only slight differences between the three cable options – Rarotonga-Samoa, Rarotonga-Tahiti and the third party cable spur and branching unit (Table 2).

**Table 2:** Economic comparison of the three SCS options

| SCS option                  | Estimated Capex (US$ millions) | Estimated Year 1 Opex (US$ millions) | Level of Cost Confidence | NPV (US$ millions) | IRR%
|-----------------------------|--------------------------------|--------------------------------------|--------------------------|--------------------|------
| Rarotonga – Samoa           | 35.9                           | 1.5                                  | 3                        | 38.3               | 13.7 |
| Rarotonga – Tahiti          | 33.6                           | 1.3                                  | 4                        | 43.0               | 14.9 |
| Third party spur & branching unit | 33.7                          | 1.0                                  | 2                        | 47.1               | 15.7 |

Assumptions:
- WACC 6%
- Financial lifetime 15 years

5.6 Selecting a Preferred Cable Option

A cable to Samoa is the most expensive option in terms of capital cost and gives the lowest NPV. It has the additional disadvantage of uncertainty as to if, when, and to where a replacement for the ageing ASH cable system will be implemented. It also carries a slightly reduced level of confidence in the budgetary pricing as unlike the Tahiti option it has not proved possible to obtain a Landing Party ROM quotation from the owner of the Apia CLS. Nevertheless the estimate is based on widely accepted empirical industry examples and is unlikely to be lower.

The second lowest capital cost and highest NPV would be a BU and spur on a new third party cable. It would also provide Aitutaki with ample future broadband capacity without any additional cost. The risk aspects however are considerable in that:

- It has the lowest “Cost Confidence” rating due to the difficulty in predicting what the owner of the main ‘hypothetical’ cable might charge for an IRU on its cable and this cost component represents almost 30% of the capital.
- There is no certainty that such a cable from Tahiti to Fiji or Samoa will ever materialise since the main driver is Tahiti’s desire for cable diversity rather than a need driven by demand.

The Rarotonga-Tahiti option has the following benefits:

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8 Where 5 = highest level of confidence and 1 = lowest. Influenced by likelihood of option being available and confidence in cost information.
• It is the only route which carries a certainty of onward connectivity for access to the global Internet since Tahiti’s existing Honotua cable to Hawaii has sufficient capacity to assure the Cook Islands of a plentiful supply capacity to Hawaii for the foreseeable future
• OPT French Polynesia has indicated that it would be agreeable to acting as the landing party for a cable from the Cook Islands to Tahiti
• The analysis in Table 2 shows that it results in a slightly better financial outcome than the Samoan route
• Capital costs for the Tahiti route are comparable with those for the BU and spur option
• While the financial results for the BU and spur option are slightly better than for the Tahiti route, the latter carries much more certainty of implementation.
• The cost estimates for the Tahiti route come with a higher level of confidence than those for the Samoan route given the provision of a ROM quotation from OPT for acting as Landing Party.

For these reasons the Tahiti option has been selected as the most feasible cable option and it has been used for making the longer term cost-benefit comparison with the O3b satellite solution.

6.0 Submarine Cable or Satellite?

6.1 Introduction

The transport of voice and data across oceans can be achieved by submarine fibre optical cable systems or satellite transmissions and submarine cables carry over 97% of intercontinental data traffic.  

This part of the study sets out to examine the case for an international submarine cable system for the Cook Islands when compared in terms of performance and security aspects with the alternatives, namely satellite technology and in particular O3b’s new service scheduled to come on-stream in the last quarter of this year. The relative advantages and disadvantages of satellite and fibre-optic communications are well understood and it is widely accepted that for the purpose of primary international both-way communications, from a performance perspective fibre-optic would almost always be the first choice were it not for the cost constraints. An exception to this general principle would be in a land-locked country where harsh terrain makes the construction and perhaps security of a cable difficult to achieve. Satellite communication is however ideally suited for the broadcasting of TV services and for providing communications to mobile shipping, oil exploration and some military communication applications.

O3b’s MEO service, for which TCI has contracted, promises to offer significant improvements over geostationary satellite services in terms of both cost and latency or ‘round-trip delay’ so the comparisons made here are between the main

9 Submarine Fiber Optic Communications, HCom Ltd., 2011.
performance related aspects of an SCS and O3b. In Section 8.0 the financial values of each solution are then compared using a NPV analysis over a 15 year period.

6.2 Performance Comparisons

6.2.1 Latency or Delay

Latency is increasingly becoming one of the most important differentiators between satellite and terrestrial or submarine cable systems. It is the time taken for a signal to reach the distant end and is often quoted in ‘round trip time’ (RTT) or ‘round trip delay’ (RTD) which is the time taken for a signal to reach the distant end of a system and return. The laws of physics dictate that a signal sent via a geostationary satellite which has to travel almost 36,000 kms up and down will have a RTD of about 500 ms while a 6,000 km cable would have RTD of approximately 60 ms. O3b’s satellites will orbit at just over 8,000 km above the earth and they aim to achieve an RTD of less than 150 ms.10

While such differences cause only a slight degradation of voice quality they have a noticeable detrimental impact on the performance of Internet-based services and the growing number of interactive or real-time applications, the developers of which increasingly assume that the delays due to transmission will be minimal.

“As applications and services become more sophisticated and capable and as people’s expectations grow, network latency will become an increasingly important consideration for operators.”11

With the growth of ‘cloud’ services (such as e-government) and their attractiveness to smaller less developed countries in terms of lower cost an SCS would certainly lower the risk of being unable to use future and as yet unknown applications which call for minimal levels of latency.

6.2.2 Capacity

The system or design capacity of submarine cables is many times higher than that intrinsically available from satellites. Due to major advances in opto-electronic technology SCS are now usually capable of being upgraded to as much as five times the original system capacity. The capacity of an individual satellite is however fixed for the lifetime of the satellite and once it is launched it is not practically feasible to recover a satellite in order to increase its capacity.

The preferred submarine cable option as described previously would have an initial system design capacity of over 1.2 Tbps with an initial ‘lit’ or enabled capacity of 10 Gbps. These capacities are ‘full duplex’ which means unlike satellite capacities quoted the bandwidth is available in each direction simultaneously.

In the case of O3b and the Cook Islands an initial (simplex) capacity of 622 Mbps will be available using the 4.5 metre ground terminal being deployed. Expanding beyond

10 “The driver behind the orbital altitude is to achieve a roundtrip latency of less than 150 milliseconds” Brian Holtz, O3b CTO, Aviation Week & Space Technology, April 2013.
this capacity will require the installation of an additional ground terminal at Rarotonga. An additional 2.5 metre terminal would provide an extra 585 Mbps of simplex capacity.

Note that the simplex capacity of a satellite means that the stated amount of bandwidth needs to be shared between the ‘up’ and ‘down’ requirements. It is understood that the O3b capacity for the Cook Islands will be configured in a 1.5 to 1 (down to up) ratio so, for example traffic requiring 600 Mbps of ‘duplex’ cable capacity would 1,500 Mbps of ‘simplex’ capacity on a satellite.

An SCS when compared to any satellite solution would assure the Cook Islands of a ‘future proof’ supply of capacity sufficient to meet any future possible needs.

6.2.3 Availability

“Availability is the degree to which a system is operational and accessible when required for use.” 12

The system availability of submarine cable systems is commonly guaranteed by suppliers as 99.95%. Not including any cable breaks which are impossible to predict this means that the maximum down-time per year will not be more than 4.4 hours. This high level of availability has been achieved over the decades that fibre-optic cables have been in use by improvements in the reliability of individual components and the duplication of every part of the system apart from the physical underwater cable itself.

In the event of a break in the submerged part of the cable it is likely that an extended outage of up to 2-3 weeks could be incurred before a cable ship could complete the necessary repair. If the break was close to shore it is possible that a ‘local repair’ could be completed in a shorter time.

O3b’s MEO system as supplied to the Cook Islands will have a quoted availability of 99.5%. Not including any catastrophic failures this equates to total downtime of 1.8 days per year. This difference is mainly due to the fact the Ka band of frequencies used by O3b are susceptible to transmission degradation during rain; this is known as ‘rain fade’. This figure can be improved greatly by installing a second ground terminal at least 30 kms from the first which provides space diversity and will minimise rain-fade. This would however effectively double the cost of the ground terminal installation.

In the event of a satellite failure the O3b system will still function since the initial constellation will contain 8 satellites and theoretically, depending on traffic loading, only 5 would be required to continue provision of service.

The most vulnerable part of the O3b system as supplied to the Cook Islands will be the ground terminal. As the satellites are moving across the earth they need to be tracked by the ground station. This consists of two dishes which work together to ensure an uninterrupted transmission as one satellite disappears over the eastern horizon and another rises in the west. The system can only work if both tracking dishes are fully functional. O3b has stated however that any failure of a tracking

12 IEEE-90 definition.
terminal can be repaired within the approximately 40 minute windows that exist before the terminal needs to pick up the ‘rising’ satellite. This will certainly require the availability in Rarotonga of skilled, well-trained technical resources in order to affect any such necessary repair.

Whether the primary means of international communication is submarine cable or O3b it will be necessary to retain other capacity for backup purposes in the case of a failure to carry traffic albeit at reduced performance levels, until the primary system is restored.

6.2.4 Natural and Man-made Hazards

6.2.4.1 Submarine Cables

Despite the precautions taken with design and installation, it is always possible that there could be a cable system interruption. Environmental risk can be created by man-made or natural hazards. Examples of man-made hazards include ships’ anchors, dredging activities, busy ports, certain types of fishing, and under-sea mining. Risk can also be created by natural events such as subsea earthquakes, tsunami, subsea volcanic eruptions, turbidity and even damage from large marine creatures such as sharks. The principal protection against environmental risk is by careful selection of a cable route and landing points which, while seeking the shortest path, will always be routed to avoid such hazards. Additional measures and tools designed to minimise this type of risk are:

- notifying and obtaining the cooperation of local authorities
- creating prohibited anchorage zones where necessary
- burial of cable in shallow waters deemed vulnerable
- heavy armouring of cables where risk of physical damage may exist.

Fortunately the South Pacific is a relatively benign subsea environment and this, combined with highly professional route design, has seen only three deepwater interruptions from external aggression in the past 15 years across all the installed cables in the Pacific. Based on those statistics, the probability of a failure can be considered low.

The fact that a Cook Islands SCS would lie in very deep water provides it with strong natural protection against sabotage or terrorist attack. The route of the more vulnerable backhaul or land section would be buried and the route known to very few. Cable landing stations would have the normal security systems and measures required for protection as would any important international telecommunications facility.

6.2.4.2 Satellites and O3b

The susceptibility of the Ka frequency band to rainfall and how this can be successfully mitigated against has already been discussed in Section 6.2.3.

Cyclones pose a threat to the operation of any satellite system since the ground antenna system is engineered to tolerate certain maximum wind-speeds before damage could occur. The manufacturer will normally specify the level of gusts and
sustained wind speeds that can be tolerated before the antenna will need to be stowed (typically turned on its back) which takes it out of service. In the case of O3b and TCI’s 4.5 metre antenna on Rarotonga it must be stowed when winds gust to more than 96 km/h. The ‘survival’ rating of the antenna in the stow position is 161 km/h – at wind speeds greater than this the manufacturer does not warrant the ‘stowed’ dish against further damage.

Space debris and solar storms also present risks to satellites. Solar storms, also known as coronal mass ejections, emit very large amounts of radiation which can interfere with transmissions and, in extreme cases, can disrupt the functionality of the satellite. To protect against solar radiation, special designs, materials and redundancies are used so that critical electronic components are properly isolated and protected from a large and sudden influx of high voltage solar particles. Space debris fragments also pose a threat to operating satellites, although the danger is greater in the densely populated low earth orbits than in O3b’s MEO.

In June last year Thierry Collot, the Managing Director of SpaceCo and Head of Aviation and Space Underwriting at AGCS France said “The space debris situation has become irreversible. Risks are actually increasing as objects collide and produce fragments”\(^{13}\)

Finally for the sake of completeness, sabotage by jamming or the deliberate interference with the transmission capability of satellite is a very rare occurrence in normal commercial systems. It is however very difficult to guard against and is of real and growing concern to satellite users such as the US Military with its huge dependency on communication satellites.

In summary given that submarine fibre-optic cables have been around for over 30 years (and their co-axial and copper predecessors for 70 and 120 years respectively) there can be little doubt that from purely a performance perspective an SCS represents a higher performance and lower risk long term solution for the Cook Islands’ broadband capacity needs than the innovative and ground breaking but as yet unproven O3b system.

7.0 Demand analysis

Projections of wholesale demand for bandwidth were derived from a bottom-up analysis of retail demand. Separate projections were developed for:

- international fixed voice
- fixed broadband
- international mobile voice
- international SMS
- mobile broadband
- international leased circuits.

We derived forecasts for fixed lines, fixed broadband subscriptions and mobile subscriptions, together with profiles of average usage per subscription (in terms of minutes for voice telephony or MB for broadband services). The average usage comprised incoming and outgoing traffic that requires international connectivity.

\(^{13}\) Space Risks: A New Generation of Challenges, Allianz (June 2012)
These forecasts were used to derive projections of bandwidth per service (in Mbit/s) given assumptions on peak demand. Projections for international leased circuits (in Mbit/s) were added to the aggregated bandwidths per service to obtain total bandwidth.

As is the case in other markets worldwide, demand for international bandwidth in the Cook Islands (Figure 7) is being driven by the take-up of broadband services – both fixed and mobile. International voice telephony – based on our projections of fixed and mobile demand – is expected to require around only 1 Mbit/s of capacity over the forecast horizon of 15 years.

**Figure 7:** Projections of international bandwidth, Cook Islands, 2013 to 2031

Note: fixed and mobile voice, and mobile SMS account for a very small portion of the total bandwidth, and are not visible due to the scale of the graph.

These forecasts encompass the period 2013 to 2031. We assume for the purposes of this analysis that commercial launch of the international wholesale operator (year 1) will occur in 2017. Prior to that, international capacity is assumed to be provided by TCI via its contract with O3b. Over the period 2014 to 2016 we anticipate that TCI’s retail broadband offerings will greatly stimulate usage, in particular with significant increases in the data allowances from plans currently offered. In many retail broadband markets, retail service providers tend to maintain existing price points, offering customers greater benefits through more generous data allowances rather than reduce prices. Additional higher priced data plans with even greater data allowances may also be introduced, offering consumers an upgrade path to increased monthly spend.

Underlying our bandwidth forecasts are projections for the addressable market based on population projections from the Cook Islands Statistics Office\(^ {14} \). We have used the high growth scenario for those projections, as we consider that the presence of an SCS is likely to stimulate population growth.

\(^{14}\) *Cook Islands Population Projections (2006).*
Fixed broadband

TCI is anticipating further strong growth in fixed broadband services in the short term. We note that in comparison with other Pacific island nations, the Cook Islands have a relatively high uptake of fixed telephone lines, and thus we believe that the market for fixed broadband will continue to be strong over the medium to long term. Our projections assume that fixed broadband penetration (subscriptions per 100 persons) would increase to a level comparable with that of the current level of the top ten OECD countries by 2028.

As noted above, we anticipate that there will be a step change in usage in 2014. In that year, we assume that average data usage per month would be 2GB, and this will increase by 20% per year thereafter. Note that the data allowance for the highest TCI broadband plan (as at April 2013) is 55MB.

It is clear that broadband users in the Cook Islands are eager for greater data allowances. Many people have connections through education, family and friends with New Zealand and Australia and are well aware of typical data allowances available in those markets. Greater data allowances will be able to deliver a far richer interactive experience with real-time applications, and facilitate the download of large volumes of content.

Certain sectors of the Cook Islands market have been examined separately, as due to the small market size, these users may have a disproportionate effect on total bandwidth demand.

We have assumed that a small proportion of businesses will be heavy users of fixed broadband services. Examples of such businesses would be hotels and financial institutions. These businesses are assumed to use on average 10 GB per month in the 2013 base year, increasing by 20% per year.

Schools will be another sector with heavy broadband usage. From information supplied by the Ministry of Education around two thirds of schools are currently on plans with data allowances of 3 GB per month – four schools are on a higher data allowance, and seven schools have a lower data allowance. We have assumed a step change in usage in 2014 with the availability of more international capacity from an average of 3 GB to 10 GB per school per month, and subsequently increasing by 20% per year due to greater usage of high bandwidth applications.

While health services will be significant users of broadband services, particularly for videoconferencing and telehealth applications, a large part of this high bandwidth traffic is likely to be domestic rather than international. Current domestic bandwidth can only support telehealth consulting, and is insufficient for clinical cases. We have assumed that the 74 health facilities – hospitals, health centres, dental clinics and child welfare centres – in the Cook Islands are heavy broadband users, with an average data traffic of 5GB per month per facility in 2014, increasing by 20% per year. High quality video to support remote telehealth applications such as clinical diagnosis and remote surgery may require even more bandwidth, however in order for these types of applications to be feasible, domestic high bandwidth services must be also be available at the required locations.
7.2 Mobile broadband

As noted above it is anticipated that TCI will launch 3G mobile services in late 2013 or early 2014. The introduction of 3G – coupled with the increasing affordability of smartphones – is likely to lead to an explosive growth in mobile data usage. This behaviour has been observed in other markets, such as the Solomon Islands.

Our projections assume that LTE will be launched in 2018. LTE enables potentially greater bandwidths than 3G, and so we expect that the introduction of this technology will stimulate mobile data usage even further.

Take-up of 3G and LTE (Figure 8) will be driven largely by the rate of handset replacement by existing subscribers – 2.5G users will upgrade handsets to 3G, and 3G users to LTE handsets once the relevant technologies are available. We assume the average handset lifetime is three years. In addition to technology substitution overall growth in mobile subscriptions will continue – over the forecast horizon the addressable market will be approaching saturation, however users will be taking up multiple subscriptions across a variety of devices including tablets, netbooks and laptops as well as mobile handsets.

**Figure 8:** Projected mobile subscriptions by technology, Cook Islands, 2012 to 2028

Our initial usage profiles for mobile data are based on that of a 2.5G subscription. We have assumed that in 2013 the 2.5G subscription uses 50MB per month – this represents the data allowance of the lowest price mobile post-paid plan and half the allowance of the mobile prepaid data pack (according to the TCI plans as at April 2013). Given this base usage we assume that a hypothetical 3G subscription in 2013 will generate on average three times the data of a 2.5G subscription, and a hypothetical LTE subscription in 2013 four times that of a 2.5G subscription. From 2014 onwards, average usage of 3G and LTE subscriptions is assumed to increase by 20% per year, while usage of the average 2.5G subscription remains constant.
International visitors roaming on TCI’s mobile network would be a source of additional demand. We have assumed continued growth in visitors (5% per year), with visitors staying on average 8.4 days. In addition we assume that 75% of visitors will roam and that usage per visitor is comparable to that of a 3G subscription up until 2018 and of an LTE subscription from 2019 onwards.

7.3 Voice telephony and SMS

International voice telephony comprises only a small fraction of the international bandwidth, and with the adoption of low cost over-the-top (OTT) applications such as Skype and Viber we anticipate that traditional international voice traffic is unlikely to increase significantly.

SMS traffic requires very little bandwidth, and so this traffic is negligible in comparison with the other traffic components. Furthermore, as in the case of voice telephony, there is likely to be substitution of international SMS by alternative applications such as Skype IM, Windows Live Messenger and Facebook.

7.4 International leased circuits

There are currently a very small number of international leased circuits. We would expect these to be taken up by corporate customers, such as financial institutions. Over time, the applications that utilise such circuits are likely to be enhanced and so those end customers are likely to require additional capacity. This could be achieved via higher bandwidth leased circuits, or alternatively high bandwidth broadband services with large data allowances, depending on the requirements of the customer.

We have assumed that over the forecast horizon the number of international leased circuits will remain constant, however the capacity per circuit will be increased:

- 2014 – the existing 256 kbit/s circuits are upgraded to 2 Mbit/s
- 2019 – circuits are upgraded to 10 Mbit/s.

One significant end customer for international connectivity is likely to be the University of the South Pacific (USP). The Cook Islands campus currently utilises bandwidth supplied by USP’s network (via VSAT) plus additional broadband capacity from TCI. USP’s network enables a range of applications – including audio and video conferencing, as well as Internet access – supporting distance learning and communications between campuses across the Pacific. At the Cook Islands campus in 2011 there were eight staff and 240 students. According to USP there is currently sufficient demand for the Cook Islands campus to warrant bandwidth of 10 Mbit/s. Our projections assume an annual growth in bandwidth of 20% from this base level of demand. This increase in bandwidth aims to support greater numbers of students (USP noted that overall enrolments typically increase by around 10% per year), together with increased usage of high bandwidth applications, such as multiple simultaneous video conferencing sessions. There is a possibility that a new faculty or research centre may be established in the Cook Islands during the forecast period, in which case there will be a corresponding step increase in bandwidth demand, however we have not included this outcome within our projections due to its
uncertainty. We note also that the availability of sufficient international bandwidth may be a significant factor in selecting the location for such a facility.

8.0 Financial & Economic Comparison

A key input to the financial analysis is the choice of weighted average cost of capital (WACC), or discount rate. Figure 9 illustrates the effect on NPV of variations in the WACC. Even though the O3b solution has a higher IRR than the SCS solution, for WACC values less than 8.8%, the SCS solution is a better investment, as it has a higher NPV.

The ADB uses a social discount rate of 10% of 12%, however the availability of loan or concessional funding will have the effect of reducing the risk of the investment, and thus also the WACC. A similar venture in the Solomon Islands provides a real-life example of a lower discount rate due to the nature of the funding – in that case the WACC used is 3.75%. We therefore believe there is a strong case for using a WACC lower than the ADB’s social discount rate, however to be conservative our analysis is based on a WACC of 6%.

Figure 9: Financial comparison of SCS Tahiti route with O3b option, for given WACC values

8.1 Capital costs

The estimated capital cost for the SCS Tahiti route is US$33.6 million. This includes:

- equipment, plant and services – subsea and land cable, including spares

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• other purchaser costs, such as permits, land acquisition and construction, landing party arrangements and SCS supply contract implementation costs
• contingency allowance for additional capital if required (10%).

Capital costs for the O3b solution comprise $1.1 million in year 0 (2016) plus additional capital incurred in subsequent years as demand increases and extra antennae are necessary to deliver the required capacity. These costs include:

• equipment, plant and services – namely additional dishes (including spares) to support increased demand
• contingency allowance for additional capital if required (10%).

The capital costs for both options do not include financing costs, due to the inclusion of the cost of capital in the calculation of net present value (NPV). Furthermore establishment fees, commitment fees and other financial charges are transfers between beneficiaries and do not represent consumption of resources.

Retail service providers will also incur capital costs for the upgrade of network and business capacity to meet the requirements of additional retail demand. Such investment will to some degree be offset by the elimination of the need for geostationary satellite capacity (assuming that TCI’s O3b solution will continue to be utilised for domestic connectivity and network resilience).

8.2 Operating costs

Operating costs for the SCS solution include:

• operations and maintenance costs – encompassing the submarine cable, landing stations, IRU, site rental and provision of a repair fund (assumptions and trends for these were based on international experience)
• connectivity costs for access to the Internet at the cable B end – proportional to bandwidth demand, and with the per-Mbps costs reducing over time consistent with experience elsewhere
• indirect (non-network) costs – general business costs, including back office functions.

Operating costs for the O3b solution include:

• operations and maintenance costs – capital operating expenditure (assumed 15% of the capital costs) and site rental
• bandwidth cost – usage charge for the O3b satellite, proportional to bandwidth demand (assumed to be constant over time)
• indirect (non-network) costs – general business costs, including back office functions (assumed to be the same as for the SCS solution).

Retail service providers will also incur additional operating expenses associated with the additional level of demand. Again these will be offset to some degree by the reduction in costs due to the elimination of the requirement for geostationary satellite capacity.
Note that the operating costs for the SCS Tahiti route (Figure 10) are quite low in comparison with those for the O3b option (Figure 11).

**Figure 10:** Projected financial performance of the SCS Tahiti route, 2017 to 2031

![Projected financial performance of the SCS Tahiti route, 2017 to 2031](image)

**Figure 11:** Projected financial performance of the O3b option, 2017 to 2031

![Projected financial performance of the O3b option, 2017 to 2031](image)

8.3 Revenue

Revenue for the wholesale operator is driven simply by price multiplied by bandwidth demand.
In the case of the O3b solution, the analysis assumes that the wholesale price remains constant over the financial lifetime. This is due to cost composition of the O3b solution, namely that it is driven largely by operating costs with no reducing cost trends. This wholesale price is set to be the bandwidth cost (as described under the breakdown of operating costs above) plus a margin of 50%.

A higher wholesale price could in theory be charged for the SCS service, due to the higher quality (that is, lower latency), however for many consumers the quality of the O3b solution is likely to be acceptable, subject to the technology achieving the anticipated level of performance claimed by O3b. Furthermore, TCI can continue to provide capacity on its contracted O3b service, for at least the first few years of the new wholesale operation, and potentially for a longer period if a new contract is implemented after the 5 years of the initial O3b contract. The SCS business may therefore struggle to achieve market share if it charges a wholesale price higher than that of an O3b solution, and hence our assumption is that the wholesale price would need to be no greater than that of the O3b service.

Our analysis also assumes that once the SCS operating costs achieve a certain threshold, the wholesale price will be reduced by 2.5% per year. This threshold is achieved if the SCS operating costs divided by the bandwidth demand, plus a margin of 50%, is less than the wholesale price of the O3b solution. The feasibility of such a reduction would depend on whether a significant part of the capital could be written off through loans or concessions. Given our demand projections, this threshold is achieved in 2017 (year 1).

8.4 Sensitivity Analysis

In addition to testing the sensitivity to WACC, we also undertook a sensitivity analysis of several key factors – capex, opex and bandwidth demand – for the Tahiti route (Table 3) and the O3b option (Table 4). We also examined the outcome for the combined worst case scenario.

**Table 3:** Sensitivity analysis of Tahiti route

<table>
<thead>
<tr>
<th></th>
<th>Base case</th>
<th>Capex +10%</th>
<th>Opex +10%</th>
<th>Demand -10%</th>
<th>Worst case</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV ($, millions)</td>
<td>43.0</td>
<td>39.7</td>
<td>41.3</td>
<td>33.8</td>
<td>30.9</td>
</tr>
<tr>
<td>IRR</td>
<td>14.9%</td>
<td>13.8%</td>
<td>14.6%</td>
<td>13.4%</td>
<td>12.3%</td>
</tr>
</tbody>
</table>

Assumptions:
- WACC: 6%
- Financial lifetime: 15 years
Table 4: Sensitivity analysis of O3b option

<table>
<thead>
<tr>
<th></th>
<th>Base case</th>
<th>Capex +10%</th>
<th>Opex +10%</th>
<th>Demand -10%</th>
<th>Worst case</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV ($, millions)</td>
<td>31.9</td>
<td>31.3</td>
<td>23.2</td>
<td>28.2</td>
<td>19.7</td>
</tr>
<tr>
<td>IRR</td>
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<td>58.7%</td>
<td>49.5%</td>
<td>57.3%</td>
<td>42.0%</td>
</tr>
</tbody>
</table>

Assumptions:
- WACC: 6%
- Financial lifetime: 15 years

Given the capital-intensive nature of the SCS, its sensitivity to variation in capex and bandwidth demand, combined with a relative insensitivity to opex, is to be expected. By contrast, the O3b option is driven largely by opex, and thus we observe sensitivity to variation in opex, but lack of sensitivity to variations in capex. The O3b option is also moderately sensitive to variations in bandwidth demand.

8.5 Financial and Economic Benefits

Many of the benefits that will be realised through an SCS solution apply equally to the O3b solution, namely additional bandwidth capacity at a lower price than is the case for the current situation where international connectivity is supplied by geostationary satellite. This additional capacity, whether delivered via SCS or O3b, will:

- Increase take-up and usage of fixed and mobile broadband services via lower retail prices
- Encourage adoption of online services and applications – such as eGovernment and educational services – that will increase productivity and deliver a variety of social benefits.

Our analysis has therefore concentrated on those aspects where potential benefits of the two solutions may differ. These aspects include:

- e-Government services
- telehealth
- reversing the population decline
- e-Banking services
- increasing consumer surplus.

The economic performance of the project is shown in Table 5. This analysis is based on the Tahiti route. Further details on the calculation of the benefits appear below.
**Table 5:** Summary of Economic Internal Rate of Return calculation for the SCS Tahiti route (US$, millions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Project costs</th>
<th>SCS revenue</th>
<th>Increase in consumer surplus fixed broadband</th>
<th>Increase in consumer surplus mobile</th>
<th>Incremental population</th>
<th>e-Government</th>
<th>Telehealth</th>
<th>Total benefit</th>
<th>Net benefit</th>
</tr>
</thead>
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<tr>
<td>2016</td>
<td>33.57</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>-33.57</td>
</tr>
<tr>
<td>2017</td>
<td>1.33</td>
<td>2.10</td>
<td>0.00</td>
<td>0.00</td>
<td>1.16</td>
<td>0.58</td>
<td>0.02</td>
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</tr>
<tr>
<td>2018</td>
<td>1.40</td>
<td>2.60</td>
<td>0.02</td>
<td>0.02</td>
<td>1.31</td>
<td>0.60</td>
<td>0.02</td>
<td>4.57</td>
<td>3.18</td>
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<tr>
<td>2019</td>
<td>1.48</td>
<td>3.37</td>
<td>0.04</td>
<td>0.06</td>
<td>1.47</td>
<td>0.62</td>
<td>0.02</td>
<td>5.59</td>
<td>4.11</td>
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<tr>
<td>2020</td>
<td>1.55</td>
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<td>0.12</td>
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<td>0.03</td>
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<tr>
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<td>2024</td>
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<td>2025</td>
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<td>2026</td>
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<td>2027</td>
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<td>2028</td>
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<td>2030</td>
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<td>2031</td>
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<td>30.72</td>
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<td>0.94</td>
<td>0.03</td>
<td>44.24</td>
<td>41.62</td>
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</table>

EIRR: 22.0%  Benefit:Cost Ratio: 2.74
NPV: 88.4 (US$ millions)  Switching values: Costs: 174%  Benefits: -63%
Discount rate: 6%

A sensitivity analysis examined the effect on the Economic Internal Rate of Return (EIRR) of increasing the capital expenditure by 10%, increasing the operational expenditure by 10%, decreasing the demand by 10% and the worst case, being the combination of all three outcomes (Table 6). As expected the EIRR is sensitive to changes in capital expenditure and demand, but is less sensitive to changes in operational expenditure.
Table 6: Sensitivity analysis of Economic Internal Rate of Return calculation for the SCS Tahiti route

<table>
<thead>
<tr>
<th></th>
<th>Base case</th>
<th>Capex +10%</th>
<th>Opex +10%</th>
<th>Demand -10%</th>
<th>Worst case</th>
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<tr>
<td>EIRR</td>
<td>22.0%</td>
<td>20.5%</td>
<td>21.7%</td>
<td>20.8%</td>
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<td>NPV ($, millions)</td>
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<tr>
<td>Costs</td>
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<td>157%</td>
<td>165%</td>
<td>156%</td>
<td>137%</td>
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<tr>
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<td>-61%</td>
<td>-62%</td>
<td>-61%</td>
<td>-58%</td>
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<tr>
<td>WACC</td>
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<td>Financial lifetime</td>
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</tbody>
</table>

8.5.1 E-Government services

E-Government services can deliver productivity increases – both through increasing efficiency of government processes, and by decreasing the amount of time spent by people requiring government services.

Currently most transactions must be made in person in the appropriate government office in Avarua, which incurs both travel time, as well as the time for the actual transaction. Most transactions require around 30 minutes (including wait time), however some transactions can take considerably longer. In addition, travel time for those from islands other than Rarotonga can be considerable and may incur several days away from home. Consequently, people from the other islands typically schedule a number of government transactions within a single trip to Avarua.

We have assumed that e-Government services will become available by 2017, and that the SCS solution would be preferred over O3b due to its lower latency. We have estimated the savings that would accrue if transactions were made online rather than in person. These savings are based on assumptions regarding the average number of activities or transactions (Error! Reference source not found.). We assume that people living on Rarotonga would have on average two transactions per month, and save 60 minutes per transaction. Those living on the other islands are assumed to combine an average of six transactions into a single activity, with one activity per quarter, and save 780 minutes per activity.

Table 7: Assumptions for cost savings achieved from e-Government services

<table>
<thead>
<tr>
<th>Persons living on:</th>
<th>Rarotonga</th>
<th>Other islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of activities per year</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>Average time saved per activity (minutes)</td>
<td>30</td>
<td>180</td>
</tr>
<tr>
<td>Average travel time saved per activity (minutes)</td>
<td>30</td>
<td>600</td>
</tr>
<tr>
<td>Time saved per person (hours per year)</td>
<td>24</td>
<td>52</td>
</tr>
</tbody>
</table>
The resultant savings to be achieved via e-Government were calculated by applying the estimated GDP per capita per working hour, assuming 2000 working hours per year. The savings that would be due to the SCS were assumed to be 10% of the total savings.

8.5.2 Telehealth

As discussed in Section 6.2.1 one key performance advantage of an SCS solution over O3b is lower latency. Telehealth is an area where high bandwidth and low latency are essential for certain real-time applications, such as those involving telesurgery or clinical diagnosis. These will certainly be possible with an SCS solution, however physical trials will need to be performed in order to establish whether the performance characteristics of the O3b solution are sufficient for these types of applications.

The Ministry of Health has a budget for patient referral – NZ$550,000 for each of the three years from 2012-13 to 2014-15. This supports the referral of patients to access services both within the Cook Islands and in New Zealand. We have assumed that this amount would be increased by 2% in subsequent years, and that telehealth initiatives would save 25% of this cost, of which 20% would be due to the SCS.

It is clear that this will be a very conservative estimate of the benefits that would accrue from telehealth initiatives. There will also be time saved through the reduced need to transport patients to health facilities, which is also likely to result in improved health outcomes.

8.5.3 Reversing the population decline

The availability of the SCS will be a key driver in supporting population growth. Barriers to temporary or permanent migration are relatively low for Cook Islanders, who are readily able to relocate to New Zealand or Australia for employment or education.

There are examples in which broadband infrastructure has played a key role in reversing population decline in remote regions – such as Hudiksvall in northern Sweden where deployment of an FTTH network was successful in attracting new businesses. We anticipate that similar benefits would be achievable with the deployment of an SCS solution, improving employment prospects and encouraging Cook Islanders to return from abroad.

The Cook Islands Statistics Office developed three sets of population projections from the 2006 Census. The medium projections reflect a stagnant population, with a compound annual growth rate of only 0.25% over the period to 2030. Over the same period the compound annual growth rate of the high projections is 0.80%, which results in an increase of almost 2300 persons by 2030.

We have assumed that economic growth under the high population projections would be increased by the additional population (relative to the medium projections).

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17 Projections based on the 2011 Census are not yet available.
multiplied by GDP per capita; and that 5% of this economic growth would be due to the SCS. This is a relatively conservative assumption.

8.5.4 e-Banking services

Banking facilities are available on almost every island, with the exception of Nassau, Palmerston and Suwarrow, which hold around 0.7% of the population according to the 2011 Census. The two banks with the greatest market share – ANZ and Westpac – have a smaller footprint than BCI. Internet and mobile banking services are also currently available.

The larger data allowances expected to be offered by both O3b and the SCS solution will reduce one barrier for e-banking usage. The benefits would however be similar for both solutions, and so they have not been included in the estimation of economic benefits.

8.5.5 Increase in consumer surplus

As noted in Section 8.3 the financial analysis of the SCS solution has assumed that the wholesale price declines over time while that of the O3b solution remains constant. Note that the feasibility of this strategy will also be dependent on any constraints that may be imposed due to financing costs.

If this reduction in wholesale price is translated into lower retail prices, then the savings achieved would be a benefit for consumers. This increase in consumer surplus will be proportional to the relativity of the wholesale prices of the two options. Our calculation of the increase in consumer surplus has assumed that the cost of international connectivity is 15% of the retail price, and that the full reduction in the SCS wholesale price is passed on to consumers.

8.5.6 We note that the most likely response by retail service providers would not be to reduce retail prices, but rather to hold retail prices constant at the existing price points and increase the data allowances. Therefore consumers may receive the consumer surplus in terms of increased usage rather than in a reduction in spend. Other benefits

The other major benefit of the SCS solution over O3b is that it will be able to deliver an extremely large amount of additional capacity for very little incremental cost. In other words, the SCS solution offers considerable economies of scale that are not possible with O3b. While the O3b solution can potentially deliver additional capacity, there are no associated economies of scale, and thus no savings as demand increases. Normal volume discounts may apply but the resultant savings cannot equal those of an SCS due to the finite and much more limited capacity of O3b.

9.0 Financing and Institutional Arrangements

Despite the long history of the submarine cable industry there exists no single template for how to structure a project. Each SCS is unique and financing is often a different mixture of public and private equity, commercial debt and concessional
loans and/or grants from MLDBs and other donors but different approaches continue to evolve. Some of the more common arrangements found are:

Consortium or Club Arrangement

This arrangement dates from the early days of coaxial and then fibre SCS. Invariably there was a pre-liberalisation monopoly operator at each end. It can still be used today and had the following features:

- typically financed from operating revenues
- carriers’ own capacity in proportion to investment
- IRU sales by individual owners
- capacity pricing: determined by consortium.

Private Partnerships

These were usually developed by private investors and were common during the 1990s. Some characteristics include:

- a deregulated and competitive market
- less formalised procurement processes
- IRU sales or capacity lease strategy
- deals for volume purchasers
- sales made through agents
- market pricing.

Hybrid or PPP Structures

These have become increasingly common in the last 10 years and usually involve funding by a mix of carriers, enterprises, investors, government and MLDBs. They usually:

- are well suited to niche and developing markets with special needs
- involve formalised and stringent procurement procedures to satisfy MLDB regulations
- have mandatory open RFQ and competitive bids
- use IRU sales or capacity lease strategy, published pricing
- provide deals for volume purchasers
- capacity pricing is driven by the market

Given the high capital cost of a cable and the relatively small population of the Cook Islands it is difficult to see how an SCS project could proceed without funding assistance from international donors in the form of sovereign loans and possibly a grant element in order to reduce the cost of the required capital.

As to institutional arrangements a detailed analysis of the suitability of the myriad of funding and institutional arrangements that could apply to a Cook Islands SCS is beyond the scope of this Study. The spectrum of options is very wide: one perhaps worthy of consideration would be the creation of a company which would own and operate all international infrastructure, both satellite and SCS. It would then offer wholesale services to licensed retail operators and ISPs under an appropriate regulatory framework. At this point however given that regulatory reform is planned
and discussions with TNZ regarding the future shareholding arrangement for TCI are possible it would be premature to attempt to be more prescriptive. It was thought that an examination of a current practical example from the Pacific, namely the Solomon Islands cable project, might prove more useful at this early stage to stimulate discussion and further thinking on this issue.

Telecommunication infrastructure projects such as an SCS will usually need some form of ‘sponsor’ who takes the initiative in taking it past the mere concept stage and ‘getting it off the ground’. This could be a government, an existing operator, a group of stakeholders or even an entrepreneurially inclined individual. In the case of the Solomon Islands the prime movers were Solomon Telekom and the Telecommunications Commission representing the Government.

Early technical assistance was provided by the World Bank and ADB to help stakeholders determine the best route option and prepare a detailed business case on the basis of which discussions with potential lenders could progress. During this time discussion continued as to the financing options that might be adopted. At the outset of this stage a company, SOCC\(^\text{18}\) was established to be the eventual owner and operator of the SCS and a CEO was hired to lead the project activities going forward. Whilst a small amount of seed capital was injected by Solomon Telekom (which is 66% owned by the National Provident Fund) it was agreed in the early stages that the final structure of SOCC would be agreed by the major stakeholders in the project.

The planned SOCC project funding structure which it must be emphasised is not yet final and may be subject to change, is shown in Table 8.

### Table 8: SOCC Planned Funding Structure [Source: ADB]

<table>
<thead>
<tr>
<th>Amount (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADB Sovereign Loan</td>
</tr>
<tr>
<td>Commercial Debt</td>
</tr>
<tr>
<td>SOCC Equity</td>
</tr>
<tr>
<td>Total Project Cost</td>
</tr>
</tbody>
</table>

Some further notes and observations on the SOCC funding model:

- The ADB lends to the Solomon Islands Government who will on-lend to SOCC. Clearly the ability and willingness of government is vital to a structure such as this.

- A commercial lender normally requires evidence of 30-50% equity in projects funded but in this case it treated the sovereign loan as ‘quasi equity’ thus meeting its criterion. The sovereign debt however is required to be subordinate to the commercial loan.

- Informed lenders can and will recognise a submarine cable project as a good investment which while perhaps offering a lower return than other opportunities will carry less risk than many other infrastructure

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\(^{18}\) Solomon Islands Oceanic Cable Company.
investments. With such projects uncertainty of demand and hence revenue are considered the areas of greatest risk. However in the case of an SCS in a relatively small market which could not support two competing submarine cable operators the risk is seen as lower since the first mover will invariably become the de-facto monopoly supplier of wholesale capacity to a market with a growing appetite for high speed Internet access.

- Whatever the chosen institutional or ownership structure of the SCS, sovereign and commercial lenders will require a well structured and administered regulatory framework for telecommunications which will ensure that the broadband capacity provided by the SCS will be made available on a wholesale basis in a fair and equitable manner with respect to pricing and interconnection facilities to all licensed service providers.

10.0 Conclusions and Next Steps for Consideration

10.1 Conclusions

From the performance and financial and economic analyses carried out and taking into account the limitations of this study as identified in Section 2.4 it appears that if concessional funding can be made available to the project there is a sound case for building an international submarine cable in order to meet the future broadband needs of the Cook Islands.

The case for an SCS is strongly supported by its performance advantages over an O3b satellite solution. These advantages are fully explored in Section 6.2 but can be summarised as:

- Lower latency thus a greater ability to accommodate future interactive applications
- Higher availability as unaffected by rain
- Much less risk of interruption or system damage due to high cyclonic wind speeds
- Immunity from RF interference and the possibility however unlikely of malicious jamming of satellite transmissions.
- The use of a technology that has proven itself over the last 120 years.

The financial and economic analysis shows that the SCS solution is preferable to the O3b solution if the discount rate is less than 8.8%. Given that a similar investment in the Solomon Islands uses a WACC of 3.75%, we believe that it is feasible to achieve a WACC value below the 8.8% threshold for the Cook Islands. In this case the SCS solution will be the superior investment.

The introduction of an SCS to the Cook Islands does not preclude O3b’s continued role in providing cost-effective broadband to the other islands of the group and also in providing diversity to Rarotonga in the event of a cable break and associated repair period. If a cable is deployed towards the end of TCI’s 5 year contract with O3b it may be possible for a new contract to be negotiated with O3b which would meet the
ongoing needs described here. At this point the need to continue to lease expensive geostationary satellite capacity would end.

10.2 Next Steps for Consideration

The elapsed time required to put into service an international submarine cable starting with preliminary funding and route discussions is unlikely to be less than three years. This means that in order to have an SCS in service say, at the beginning of 2017 before TCI’s current contract expires in 2018, it would be prudent to start the planning process very soon. The typical phases of an international submarine cable project are illustrated in Appendix 4.

If the Cook Islands Government decides to proceed with obtaining an international submarine cable for the Cook Islands the following schedule of activities which would see a cable in service by approximately Q1 2017 is tabled for consideration:

**Phase 1**  
**Elapsed Time:** 6 months  
**Commencing:** Jul 2013 to Jan 2014

- Establish preliminary high-level dialogue with French Polynesian and Samoan Governments as well as their respective international carriers regarding possible landing of cable from Rarotonga.

- Consider in-principle institutional arrangements for owning and operating the SCS in the light of pending regulatory reform and possible changes to the ownership structure of TCI, etc.

- Seek in-principle agreement from donors for funding assistance for the SCS project using the Tahiti route for budgetary purposes and establish approximate amounts and type of funding that the Government could and would be prepared to access.

- If needed secure initial donor funding of a Technical Assistance resource, preferably on an intermittent basis, to assist with taking the project forward to the stage of recommending an SCS system supplier following a formal tendering process.

- Continue to monitor the development of other planned SCS in the region.

**Phase 2**  
**Elapsed Time:** 18 months  
**Commencing:** Jan 2014 to Jul 2015

- Assess the demand and international capacity growth at 6 and 12 months after the introduction of O3b international service and domestic 3G mobile services to confirm that the demand growth needed to support the financial case for a cable is on track.

- Complete and review a detailed business case and plan for the equity, funding, ownership and operation of the SCS using likely or in-principle funding and institutional structures established in Phase 1 and using budgetary costs as derived from this study.
• Assess the performance of O3b at 6 months and 12 months from launch of service, with particular focus on availability and latency.

• Obtain seed capital and create a special purpose vehicle or company that will own and operate the SCS and appoint a CEO with prime responsibility for taking the project forward.

• Agree levels of sovereign lending.

• Secure the services on an intermittent basis of an experienced ‘borrow-side’ adviser who can commence negotiations with commercial lenders and help refine the financial aspects of the cable company’s business plan.

• Prepare and agree the Landing Party Agreement with distant end, e.g. OPT, Tahiti

• Confirm selection of optimal landing place on Rarotonga.

• Negotiate with land-owners to confirm that the proposed landing site is available for lease or purchase.

• Complete an environment impact assessment.

• Draw up lending agreements with all parties.

• Make a final assessment of the availability of cable route options that may have matured or failed since this study was written and if necessary modify the business case and funding plan.

• Final decision made as to cable route and funding structure.

Phase 3.  **Elapsed Time:** 6 months  **Commencing:** Jul 2015 to Jan 2016

• Prepare and issue bidding (RFQ) documents for the SCS system to be provided on a turn-key basis. (Approximately October 2015)

• Finalise Landing Party agreements

• Evaluate bids & select SCS supplier.

• Complete Financial Close. (Lending Agreements finalised, lenders’ due-diligence completed, etc.)

Phase 4.  **Elapsed Time:** 12 months  **Commencing:** Jan 2016 to Jan 2017

This is what is commonly known as the SCS construction phase which would typically require about 18 months from the time contracts are awarded. The main activities during this phase are:

• Completion of contract negotiations and the award of the contract.

• Supplier undertakes a detailed geophysical survey of the cable route.
- Supplier commences cable and terminating equipment manufacturer.

- The cable company prepares any required civil works (back-haul cable ducts, beach-manholes, etc.

- The cable landing station fit-out is completed.

- The cable company finalises agreements for the outsourcing of its operational and administrative services with local operator(s) as appropriate.

- The supplier commences the laying of the cable and installation of terminal equipment.

- Supplier commences end to end system testing and provides hands-on training of cable company technical/operational staff.

- **SCS in service approximately Q1 2017.**

### 11.0 Acknowledgements

The authors would like to acknowledge the invaluable assistance provided by many members of the public and private sector in the Cook Islands during this assignment, in particular:

- Ms Pua Hunter, Director of ICT, Office of the Prime Minister
- Mr Jules Maher, CEO, Telecom Cook Islands
- Ms Teresa Manarangi-Trott, President, The Cook Islands Chamber of Commerce

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- O3b Systems
- Alcatel Submarine Networks
- Office of Posts and Telecommunications, French Polynesia
- Hibbard Consulting
Appendix 1: Terms of Reference for Technical Consultancy

Objective and Purpose of the Assignment

The Government of Cook Islands has requested ADB to support the preparation of an assessment of the technical and institutional feasibility of developing an international fibre optic submarine cable system (SCS) for Cook Islands. The assignment will be carried out in tandem with an assessment of the financial and economic feasibility of a possible SCS.

Scope of Work

The key objectives of assignment are to (i) explore possible SCS configurations; (ii) compare the feasibility and costs of alternative SCS configurations with the O3b satellite service due to be available in 2013 and the continued use of geostationary satellites; and (iii) make an assessment of the regulatory and institutional environment in the telecommunication sector. This work will be used as an input for the Financial and Economic assessment.

Detailed Tasks and/or Expected Output

COORDINATION:

(i) Conduct strategic level discussions with stakeholders and other counterparts on behalf of stakeholders as required;

(ii) Closely cooperate with the financial and economic expert.

SECTOR AND TECHNICAL ASSESSMENT

(i) Conduct a review of the telecommunications landscape in terms of services offered, performance, cost and affordability, existing and future demand, competition policy, regulatory and institutional matters, domestic and international connectivity and infrastructure, access issues, pricing, etc.;

(ii) Canvas key public and private sector organizations and companies as well as consumer representatives to understand the negative impact if any of the current cost, availability and performance of international broadband Internet service.

(iii) Explore the most feasible configuration options for an international submarine cable system for Cook Islands, including through connection to regional cable links;

(iv) Prepare budgetary cost estimates for possible SCS configurations (including costs for the submarine cable, wet plant, marine survey and laying, terminal equipment, landing station, related civil works, indefeasible right of use (IRU), interconnection charge, operation and maintenance, management cost);

(v) Provide a cost/performance comparison between the potential SCS systems and the two satellite based alternatives; namely the existing geostationary satellite
gateway and the planned use of 03B's Medium Earth Orbit system due to become available during 2013.

(vi) Assess institutional options (ownership and governance) for a possible cable company;

(vii) Identify potential risks to the company's business viability by examining the following but not limited to: (a) regulatory challenges, technological changes, market conditions, management & technical skills etc.

EXPLORING FINANCING OPTIONS AND PLANNING

(i) Assist the key stakeholders in identifying exploring various potential private and public sector financing models.
Appendix 2: Terms of Reference for Financial and Economic Consultancy

Objective and Purpose of the Assignment

The Government of Cook Islands has requested ADB to support the preparation of an assessment of the financial and economic feasibility of developing a submarine cable system (SCS) for Cook Islands. The assignment will be carried out in tandem with an assessment of the technical and institutional feasibility of a possible SCS.

Scope of Work

In line with the approach and methodologies outlined in ADB Guidelines for the Economic Analysis of Projects, and other relevant Guidelines, the Consultant will prepare a financial and economic cost-benefit assessment of a possible investment in a submarine cable system.

Detailed Tasks and/or Expected Output

The financial and economic analysis shall comprise the following tasks:

1. Based on a review of existing data and reports (including the technical and institutional feasibility assessment) and consultations, conduct a financial and economic cost benefit analysis of the project. This should include the available cost-estimates of a possible investment, the current and forecasted situation of internet use, constraints to the use and users, profiles of current users by socioeconomic status, region, and gender, primary goals of current uses, and so on.

2. Assess how the project could contribute to national priorities as outlined in the national sustainable development plan;

3. A demand analysis for the life of the project investment;

4. A least-cost analysis that compares the life-cycle costs of the proposed investment with alternative project options using the methodology outlined in the ADB Guidelines of the Economic Analysis of Projects;

5. A discussion of the assumptions and economic parameters used in the economic analysis.

6. An estimation of the project benefits and costs in monetary terms to calculate the financial and economic internal rates of return for the potential investment;

7. The identification and analysis of likely economic uncertainties that could affect the project's viability, and undertake risk and sensitivity analysis with respect to the FIRR and EIRR; and

8. Assess the justification (or not) for a sovereign component in the financing structure of the investment.
Appendix 3: An Introduction to Submarine Fibre-Optic Cable Systems

The Evolution of Submarine Cables

A submarine communications cable is a cable laid on the sea bed between land-based stations to carry telecommunications signals across stretches of water which may be short distances or several thousand kilometres in length. Early international submarine cables laid in the second half of the 19th century consisted of a central copper conductor and carried only relatively slow speed telegraph signals (basically dots and dashes) at speeds of about 20 bits per second. They continued to be used up to the mid 1970s. More sophisticated cables of a co-axial construction capable of carrying multiple simultaneous voice communications began to appear in the 1950s. In the early 1980s fibre-optic submarine cables made their appearance after which quantum leaps in electro-optical technology have brought us to the point where we have multi-fibre cables capable of carrying 100 Gbps on each fibre over thousands of kilometres.

Fibre-Optic Submarine Cables

Fibre optic submarine cables come in two forms, repeatered and unrepeatered.

Unrepeatered Cables

Unrepeatered cable systems are used over shorter distances where electrically powered optical amplifiers along the route are not needed. The signal injected at one end is strong enough to be received intelligently at the distant end. These systems can carry a full complement of wavelengths for 400 kms. Beyond that, as the signal-to-noise ratio declines, fewer wavelengths can be achieved. At 450-500 kms, the current effective limit of unrepeatered systems, only about 2 wavelengths can be achieved. However the cable can readily contain multiple fibre pairs; as many as 20 so the reduced capacity can be offset and so the total cable capacity can satisfy most requirements.

The main advantage of unrepeatered systems is that they are less complex and less demanding of power, and thus are less expensive to operate.

Repeatered Cables

For distances beyond 450 kms, regular signal amplification along the cable length is necessary. The amplifiers are housed in containers called repeaters. These repeaters (Fig 1), which lie on the sea-bed are spaced at intervals of between 60 - 120 kms depending on the system design. This enables the cable to carry a full complement of wavelengths on each fibre pair. However because of the cost of the amplifiers, cables vary typically from one to six fibre pairs. A requirement of repeatered systems is the need to convey electrical current (as well as the optical signals) to power the repeaters so special power feeding equipment is required to provide the high voltage needed for the current to flow. This is one of the more complex pieces of equipment in a cable station, and a significant consumer of
electrical energy. The advantage of repeatered system is that they can cover up to 12,000 kms (7500 miles) without landfall.

**Figure 12:** A Submarine Cable Repeater

*Branching Units*

Typically cables are laid as point-to-point systems. Historically such systems would bypass less populous locations because of the cost, engineering and operational challenges associated with additional landings. Increasingly however, countries need greater distribution of cables so the Branching Unit (BU) was developed.

The simplest form of BU, which has been used for over 20 years, utilises what is termed a passive junction where fibre pairs are physically connected to different destinations. This type of BU is only used when there are large volumes of traffic to each destination sufficient to justify the diversion of a whole fibre pair from the main route.

In recent years, the Optical Add Drop Multiplexer (OADM) BU has been developed by means of which individual wavelengths can be picked out and diverted from the main line at a BU to different destinations. Thus if a cable passes near an island, it is possible to install a BU, and attach a spur cable off the main cable to the island. By being able to pick off only a few wavelengths, the capacity of the main route is not grossly impaired. As such the major users of the cable are more willing to accommodate spur connections to smaller communities.

**Figure 13:** A Branching Unit

*Cable Protection*

A cable represents a vital external link and in many cases the umbilical cord for a community or country. As such it needs to be protected against being damaged. The route survey which is undertaken before a cable is laid will determine a route which minimises the adverse submarine topography within reasonable economic bounds. However since cables can still experience external aggression from hazards such as earthquakes, sub-sea mudslides) and anchors and trawler gear they need to be protected to varying degrees. As a rule-of-thumb, cable sections in depths of less than 500 metres are double armoured, those between 500 and 2,000 metres are single armoured to various levels of armouring and those below 2000 metres are commonly unarmoured (the basic light weight cable). Circumstances can dictate variations and some lightweight protected cable is used up to far greater depths.
Terminal Equipment

Located within the cable station is the terminal equipment which generates the signals and the power to drive the cable system. The equipment comprises the following main elements:

- the Submarine Line Terminal Equipment (SLTE)
- the Power feeding Equipment (PFE)
- the Add-Drop Multiplex Equipment (ADM)
- the System Management tools

The SLTE generates and receives the optical waves which are sent along the cable. Its initial capacity can be increased to create more waves to meet growing demand. The SLTE also generates the supervisory tone for controlling repeaters and monitors their performance.
Appendix 4: The Project Phases of a Submarine Cable System

(Diagram: David Ross Group)