itp
The Institute of Telecommunications Professionals
www.theitp.org

The journal

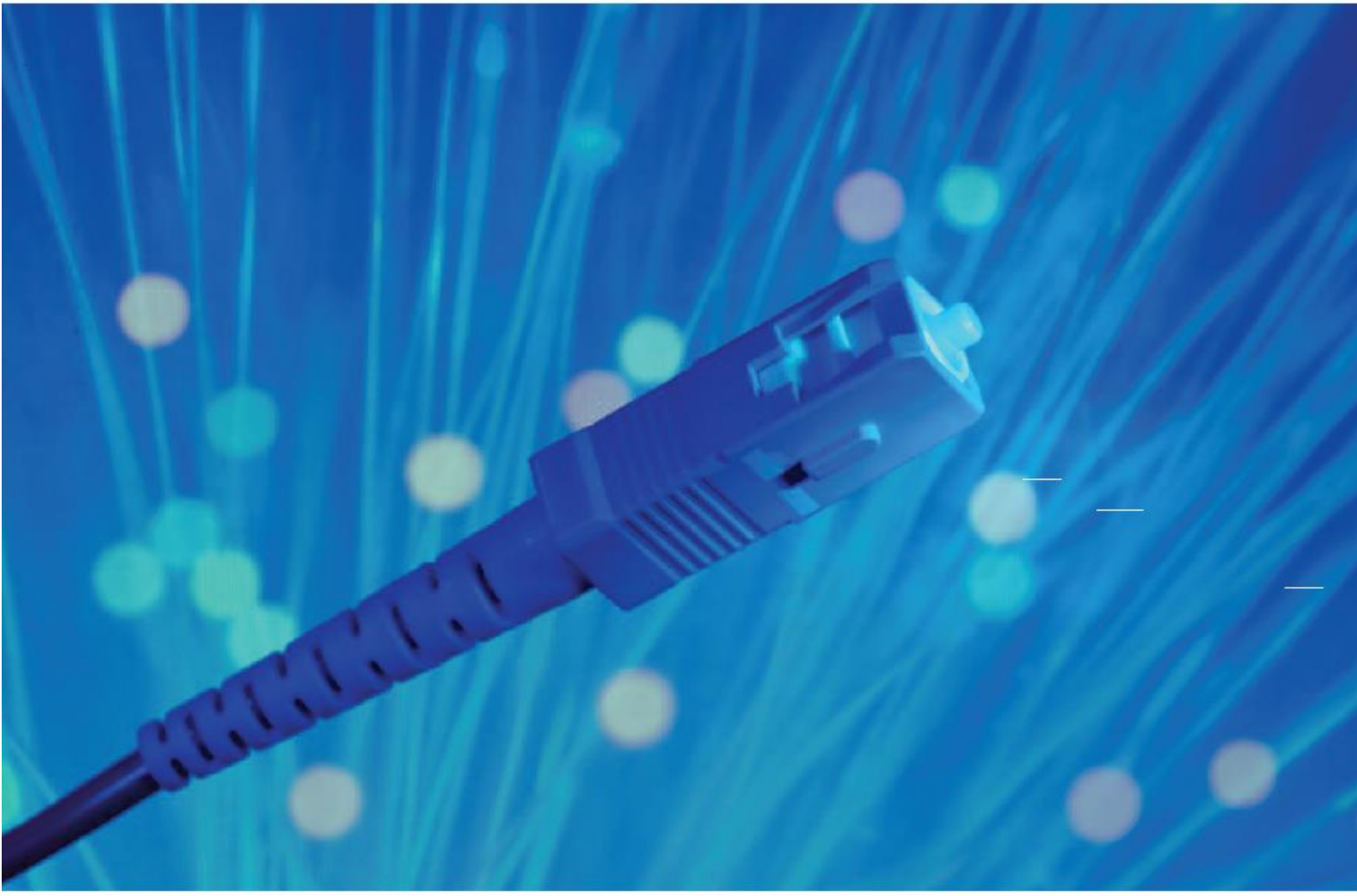
VOLUME 14 PART 3 2020

OF THE INSTITUTE OF TELECOMMUNICATIONS PROFESSIONALS

Fibre Optic Submarine Cables – increased demand and new eras

Trans-Polynesian super-highway – fibre lands on one of the world's remotest countries

Guiding light with no light at all – novel fibres and light guiding properties



Telecoms Professional magazine

– ITP Awards' call for entries

– Professional Career development

Optical Fibre and Submarine Cables

Communications – past, present and future

TAKING FIBRE TO ONE OF THE REMOTEST COUNTRIES ON EARTH

When it comes to building telecommunications networks, a large pool of customers in a small geographic area is low hanging fruit. The Cook Islands is at the other end of the spectrum. Around 17,000 people, spread across 12 inhabited islands and atolls, in a sea area half the size of the European Union and in the middle of the vast South Pacific Ocean.

Cable and Wireless serviced the islands until the late eighties. A reluctance to address the affordability of telecommunications services led the Government to intervene and establish its own solution – Telecom Cook Islands (TCI), an organisation that effectively lives on today, albeit now trading as Vodafone Cook Islands.

Until early 2020, for all of the inhabited Cook Islands, the link to the rest of the world was based on the Medium Earth Orbit (MEO) satellite system provided by O3B, part of the SES company. Its introduction in 2014 was transformational yet, compared to developed nations, prices were high, capacity limited and 'rain fade' during frequent tropical downpours and seasonal cyclones often saw the service go off-line.

Whilst a fibre optic submarine cable was the obvious answer, it would have required a double-digit percentage of the nation's Gross Domestic Product to build. With so many other priorities, this could not be the answer. Out of this necessity the Manatua Cable concept was born. A unique collaboration of four Polynesian nations created the first international development partnership of its kind in the Pacific and a plan for a trans-Polynesian information super highway – a new fibre optic lifeline.

The Manatua system design was based on two fibre pairs with a total length of 3600km. The first provided a trunk express pair between cable landing stations in Tahiti in the West and Samoa in the East with 32 optical amplifiers spaced approximately every 100km. The second pair provided an omnibus service with branches into Rarotonga and Niue. Bora Bora to Tahiti and Rarotonga to Aitutaki in the Cook Islands was serviced via a separate dedicated fibre pair spur.

With the South Pacific being typically 4-5 km deep, and the islands being steep sided extinct volcanoes often with 70-degree inclines, the greatest risk of damage to the cable is in the last kilometre as it comes ashore. Most of the cable is only 19 mm in diameter in the deep water where hazards are rare but armouring is essential for higher risks areas if the cable is to withstand the worst that nature can produce over a its required 25-year system life.

After two years of preparation, marine surveys, design reviews and a lot of testing, the Manatua One Polynesia cable was ready to be laid in November 2019. The laying activity itself is quite a remarkable feat. In 5km of water depth, the cable will often not touch the seabed until 50km behind the vessel and accurate placement requires vessel positioning with an accuracy of 1-2m and forensic control over cable tension in a variety of sea states and weather conditions.

The cable landings were an exciting event for the local people who had waited so long for improved connectivity. In both Aitutaki and Rarotonga, a party atmosphere welcomed the landings with traditional drumming and dancing together with speeches and prayers from dignitaries including the Prime Minister and traditional leaders.

Landing the cable was only half the job as each of the partners in the Manatua Consortium had also to construct their own Cable Landing Station to house transmission, cable powering and monitoring systems as well as providing duct route to the beach manhole where terrestrial ('dry') and marine ('wet') cables were connected. It was also necessary to create a new telecommunications operator and a commercially sustainable business.

In May 2020, ACL went live as a wholesale fibre operator, initially selling fibre services to Vodafone Cook Islands whilst looking to encourage new market entrants. As a result, local people have experienced cheaper, faster, more responsive, more reliable and resilient services and fibre connectivity is seen as the key enabler for diversifying the economy from an over reliance on tourism. All of this from a few strands of optical fibre sitting quietly 5km beneath the South Pacific.

Turn the page for the full article.

ANY COMMENTS?
Write in with your news, views and comments at the usual address (see p3) or email us on letters@theitp.org.

TAKING FIBRE TO ONE OF THE REMOTEST COUNTRIES ON EARTH

Most first-world countries are deploying ever faster internet broadband services to homes and businesses, increasingly with optical fibre, unlimited data and low monthly charges. It's easy to forget that the revolution has not reached everywhere, explains Ranulph Scarbrough, The Manatua One Polynesia Submarine Cable being one such example. Here he explores the challenges of connecting the unconnected. (Pictured above: The landing of Manatua 1 on Rarotonga.)

When it comes to building telecommunications networks, a large pool of customers in a small geographic area is low hanging fruit. The Cook Islands is at the other end of the spectrum. Around 17,000 people, spread across 12 inhabited islands and atolls, in a sea area half the size of the European Union and in the middle of the vast South Pacific Ocean. Indeed, when I first tried to locate the archipelago, Google readily obliged. Yet every time I zoomed out to see what they were near, frustratingly, the pin-prick islands would vanish. They are small.

In recent decades, a healthy tourism sector has developed. There are often three international flights each day and in January 2020, the Cook Islands obtained OECD[1] developed nation status. The first Pacific islands to do so.

Cable and Wireless serviced the islands until the late eighties. A reluctance to address the affordability of telecommunications services led the Government to intervene and establish its own solution – Telecom Cook Islands (TCI), an organisation that effectively lives on today, albeit now trading as Vodafone Cook Islands. And some current staff fondly recall training in the Cable & Wireless college at Porthcurno, in my native Cornwall. A small world.

[1]The Organisation for Economic Co-operation and Development (OECD)

RANULF SCARBROUGH

The Manatua Cable concept

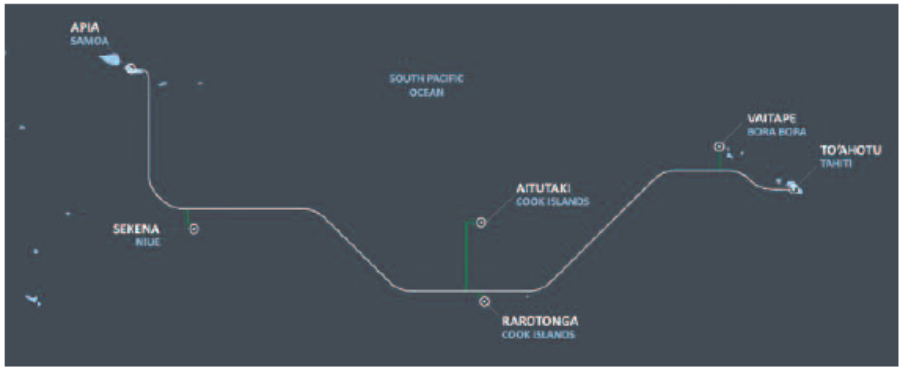


Figure 1: Manatua One Polynesia Cable System Map.

Fast forward to 2020, and Vodafone services all of the inhabited Cook Islands with the link to the rest of the world still based on satellite. The Medium Earth Orbit (MEO) satellite system is provided by O3B, part of the SES company, and services over 90% of the population. Its introduction in 2014 was transformational yet, compared to developed nations, prices are high, capacity is limited, 'rain fade' interrupts service during frequent tropical downpours, and seasonal cyclones can require the service to go off-line. A local joke is to spot hapless tourists looking for cafes with free Wi-Fi. High internet prices have meant there are none.

A trans-Polynesian information superhighway

While a fibre optic submarine cable is the obvious answer, these do not come cheap and would require a double-digit percentage of the nation's Gross Domestic Product to build. With so many other priorities, this could not be the answer. They say necessity is the mother of invention. Out of this necessity the Manatua Cable concept was born. A unique collaboration of four Polynesian nations – each investing and securing their own benefit – and with the New Zealand government as matchmaker. The Manatua International Treaty, signed by each nation's Prime Minister, created the first international development partnership of its kind in the Pacific and a plan for a trans-Polynesian information super highway – a new fibre optic lifeline.

Office des Postes et Telecommunications (OPT), French Polynesia's state-owned incumbent operator, would connect Tahiti and Bora Bora, which would provide a backup to their existing Honatua cable to Hawaii. Funding would come from French Government's Agence Française de Dévelopement and the European Investment Bank. Telecom Niue would lead for the tiny island state of Niue and secure their first cable connection. Avaroa Cable Ltd was established by the government in the Cook Islands and would connect the two most populous islands – Rarotonga and Aitutaki. Funding would come from the New Zealand Aid Programme, who would also support Niue, and the Asian Development Bank. And the Samoa Submarine Cable Company would be the landing party for Samoa, providing a third cable to the state, supporting their ambition to be a regional connectivity hub. If that all sounds complex, that's because it was.

Getting to work

A lengthy and robust procurement process – a necessity to satisfy the diverse donors and funders – resulted in US company Tyco Electronics Subsea, since renamed SubCom LLC, being selected as the turnkey provider. A brief lull in the subsea cable construction market, led to a keenly priced deal.

Contracting as a consortium is never easy. When backed by a labyrinth of funders and governments, each with their own views and constraints, this made closing the deal perhaps one of the most challenging elements of the project. However, in November 2018, the project acquired the submarine cable industry's mystical status – "Contract in Force".

Fortunately, the Manatua Cable Consortium was not the first group seeking to manage the build and operation of a submarine cable. There is a long history of Construction and Maintenance Agreements designed to help, what are essentially competing organisations, to collaborate. Sometimes with literally hundreds of parties. Our agreement would become our bible for cooperation.

In technical terms, the Manatua system design would be for two fibre pairs with a total length of 3600km. The first would be a trunk express pair between Tahiti and Samoa cable landing stations, which would also house the 11 kV power feed equipment for driving the 32 optical amplifiers spaced every 100 km or so. The second pair would be an omnibus service with branches into Rarotonga and Niue. Bora Bora to Tahiti would have its own separate dedicated fibre pair as a domestic system within French Polynesia. As would Rarotonga to Aitutaki in the Cook Islands. For this link, the 365 km distance would be too great to have no amplification. To avoid costly repeaters and power feed equipment, high-power Raman laser pumps at each end would be used to create amplification within the fibres. While an elegant solution, this would create technical issues, such as requiring all joints to be spliced due to the high power – up to 5W – and for fibres to be mechanically encased to avoid safety risks of any light leakage. A schematic of the Manatua One Polynesia Cable System is shown in Figure 1.

The laser transmission equipment would be provided by Ciena, the market leader in coherent wavelength division multiplexing systems. Capacity would be 10 Tbit/s per fibre, vast even for the most ambitious traffic growth imaginable over the 25-year life of the system. However, in the submarine cable world, it is a case of one size – vast - fits all.

Marine survey and cable manufacture

Two months of marine survey, with detailed bathymetry and 3D sonar scanning along the entire cable route, was conducted in May and June 2019 in order to precisely pick the optimum cable route and avoid any seabed hazards. Armouring would then be designed into the cable where the risks of aggression were greatest. A cross-section through an armoured section of the Manatua cable is shown in Figure 2. With the South Pacific being typically 4-5 km deep, and the islands being steep sided extinct volcanoes often with 70-degree inclines, the greatest risk of damage to the cable is in the last kilometre as it comes ashore.

Cable manufacture took around three months and was carried out at SubCom's factory in Portsmouth, New Hampshire. A fascinating process to watch as the structure is built up from tiny strands of fibre, insulating tubes, power conductors, more insulators, armouring and a final coating of tar-soaked jute. Most of the cable is only 19 mm in diameter in the deep water where hazards are rare. Single or double layers of stranded-steel armouring are added for higher risks areas. Inshore, across the reefs and lagoons that encircles each of the islands, cast iron articulate pipe is clamped around the double armoured cable and securely bolted to rock or coral formations. Altogether, it's an engineering solution designed to withstand the worst that nature can produce in the 25 -year system life. This is essential as cable faults and repairs are not just disruptive, they also phenomenally expensive. Not least because of the need to mobilise a specialist ship and 60+ crew.

After rigorous post-manufacture testing, the cable needed to be transported to the South Pacific. Loading 3600km of cable into specially constructed tanks on a freighter required the team of loaders to walk backwards in a circle 24 hours a day for two weeks with strong tar vapours pervading the air – a tough job. A 15,000 km delivery journey through the Panama Canal followed. In New Caledonia the cable was transferred to the submarine cable laying ship "Reliance", where she stands by in case of regional cable breaks requiring repair. Not

Figure 2: Cross-section through an armoured section of the Manatua cable.

such an easy job given it required another labour intensive two weeks and 3,600 km of walking backwards in a circle to transfer the cable! Figure 3 shows the Mantua optical fibre being carefully stowed ahead its journey from New Hampshire to the South Pacific.

Cable laying operations

Finally, by November 2019, after marine surveys, design reviews and a lot of testing, the Manatua One Polynesia cable was ready to be laid – the culmination of over two years of preparation. Despite so much careful planning, there was still plenty of risk. The first landing in Samoa was faced with a national state of emergency due to a measles outbreak, requiring all crew to be vaccinated. Deliveries to Niue were hampered by their quay being washed away by a cyclone, which also damaged the cable landing site. Two cyclones also struck the Cook Islands before the cable could be protected with articulated pipe, the knock-on effect of a broken port tug in Rarotonga preventing the regular supply vessel from docking for several weeks. And a positioning thruster on Reliance failed just after the landing in Aitutaki, requiring the cable to be cut and buoyed, and a 1,000 km dash to Tahiti for repair – conveniently giving the crew a Christmas furlough in Tahiti. Despite these events, cable laying was completed on schedule at the end of January 2020. Figure 4 shows the Cable ship SubCom Reliance off Rutaki passage, Rarotonga on 8 January 2020 just prior to landing Manatua's Rarotonga branch cable.

The laying activity itself is quite a remarkable feat. In 5 km of water depth, the cable will often not touch the seabed until 50km behind the vessel. The detailed sonar survey is pointless if the vessel cannot hit the desired seabed path with pin point accuracy. It is vessel positioning with an accuracy of 1-2m, forensic control over cable tension and a lot of experience, while managing sea state and prevailing weather conditions, that gets the job done.

The highest risk aspect of the laying is when the cable comes ashore. It is also the most poignant. Both landings in the Cook Islands were momentous events.

In engineering terms, the landings were particularly tricky. Steep volcanic slopes from deep water. Coral reefs and heavy Pacific surf. Some 500-700m of lagoon and coral reefs to cross. Deep passages in the reef, that occur every few kilometres, were

Figure 3: The 3,600 km Mantua Cable being stowed prior to its journey to the South Pacific.

Figure 4: Cable ship "Reliance" pictured off Rutaki passage, Rarotonga. *(Courtesy Avaroa Cable Ltd)*

chosen for both landings to give the cable maximum protection. These passages are the only exits for all the sea water that breaks over the reef, making for dangerously strong currents. Figure 5 shows the "Reliance" pictured off Rutaki Reef, Rarotonga, Cook Islands on 8 January 2020 just prior to landing Manatua's Rarotonga branch cable amid heavy surf following Cyclone Sarai.

With the Reliance positioned just off the reef, a small boat is first used to bring a floating rope ashore. The rope in turn hauls in the cable, held afloat with buoys. Two excavators are required to maintain enough cable tension to ensure the routing is precisely controlled through the surf, the currents and across the lagoon. Once ashore, the floats are cut, the cable sinks in position and divers set about anchoring the cable in place and applying the armour. The cable landing alone is an all-day operation for around 50 people on the shore working closely with the team of over 60 on the cable ship.

Environmental protection is stringent and in force throughout. Public consultations are held in advance. Detailed engineering plans must also be approved by the National Environment Service (NES). And all operations are closely scrutinised by NES observers.

The landings are also exciting events for the local people who will ultimately benefit and have waited so long for improved connectivity. Much traditional drumming and dancing, speeches and prayers from dignitaries including the Prime Minister and traditional leaders, and a party atmosphere welcomed the cable both in Aitutaki and Rarotonga. Political involvement had already been critical to the project. In addition to the international treaty, three separate Acts of Parliament had also been required to facilitate the work – the Telecommunications Act 2019, the Competition Act 2019 and the Infrastructure Act 2019, all of which we were only passed in December 2019 - just in time. Figure 6 shows the landing of the cable with (left to right) the author; the Chair of the Board of Avaroa Cable Ltd (Tatiana Burn); the Cook Islands Deputy Prime Minster (Honourable Mark Brown); the Cook Islands Prime Minister (Honourable Dr Henry Puna); Aitutaki Mayor Poo.

Figure 5: The "Reliance" pictured off Rutaki Reef.

Figure 6: Containerised Cable Landing Station

Building the cable landing stations

Landing the cable is only half the job. It also needs to be terminated with a Cable Landing Station (CLS) to house the transmission, cable powering and monitoring systems. Each of the partners in the Manatua Consortium were responsible for constructing their own CLSs. The challenges are significant. Securing land, that is inshore and away from flood, cyclone and tsunami risks is tough, particularly given complex Polynesian tribal land laws. Added to this is the need to create a cyclone proof structure, with battery and diesel generator standby power, fire detection and prevention, and security. All things that are not readily available on a remote Polynesian atoll.

In the Cook Islands, we sourced two prefabricated containerised cable landing stations from DXN in Perth. The units were transported across Australia on air suspension lorries and then by ship. Port authorities damaged one of the units requiring major repairs. The unit was very nearly off loaded from the supply vessel in favour of festive stock for local shops. And then contractors struggled to create a suitable concrete plinth on which to locate the facility. Figure 6 shows Rarotonga's containerised CLS being craned into position, December 2019. The existing O3B MEO twin satellite dishes that previously connected the island are visible in the background.

Nevertheless, the containers were in place by Christmas 2019 and SubCom set to work integrating their equipment. Some 10 km of duct routes had been built from the cable landing stations to the beach landings where terrestrial ('dry') and marine ('wet') cables join in the beach manholes. With the cabling complete, Manatua system testing could begin.

It was at this point that the COVID-19 pandemic started to appear around the world. Samoa, Niue and the Cook Islands were lucky to have no cases and only a small number appeared in French Polynesia. Fortunately for the project, testing technicians were already in place at the CLSs ahead of global travel shutdowns, with the exception of Bora Bora. This meant acceptance testing could proceed. The Aitutaki to Rarotonga domestic link was the first to successfully complete testing, a milestone that coincided with a tracking mechanism failure on one of the dishes supporting the O3B satellite link that fed Aitutaki. Unbeknown to locals, the Manatua cable was quickly pressed into action to keep the island connected until a repair could be completed. For me personally, having arrived as the first employee of Avaroa Cable Limited (ACL) less than 12 months earlier, it was a proud moment to be already carrying live customer traffic in such a short space of time and against so many challenges.

Getting connected

With the Manatua One Polynesia cable in place, the focus then shifted to creating a new telecommunications operator, and a commercially sustainable business, that could deliver on the funders ambitions to transform telecommunications in the Cook Islands. ACL went live as a wholesale fibre operator in May 2020, initially selling fibre services to Vodafone Cook Islands while looking to encourage and support new market entrants. The response from people has been tremendous – experiencing cheaper, faster, more responsive, more reliable and resilient services for the first time. The government has also started to look to drive transformation in how businesses operate and compete; addressing digital inclusion; changing how government, health and education are delivered. The fibre connectivity is seen as the key enabler for a transformation of the economy, diversifying away from over reliance on tourism, something that was always needed but is all the more critical in the wake of the COVID-19 pandemic. All of this from a few strands of optical fibre sitting quietly 5km beneath the South Pacific.

The Manatua Cable is also not the end of the story, with work underway to explore the feasibility of a second cable for resilience and cables to replace the satellite connectivity to the other 10 Cook Islands, comprising 10% of the population, in order to make the benefits of cable internet available throughout the tiny Polynesian nation.

ABOUT THE AUTHOR

Dr Ranulf Scarbrough (pictured above) is CEO of Avaroa Cable Ltd and Co-Chair of the Manatua Cable Consortium, based in Rarotonga, Cook Islands. Prior to this he spent 12 years with BT Group PLC, developing the first rural fibre rollout programmes, including Superfast Cornwall which deployed 100,000 rural FTTP premises, creating the model for the UK government's fibre rollout programme. He also led BT's research into long term network evolution and collaborative innovation programmes with some of BT's largest customers. Previously he held roles in Reuters Group, Radianz Inc and tech start-up companies. A physics graduate, he holds an MSc degree from University College London, and a doctoral degree from Oxford University. He is a Chartered Engineer and a Chartered Information Technology Practitioner.

ABBREVIATIONS

MEO	Middle Earth Orbit
CLS	Cable Landing Station