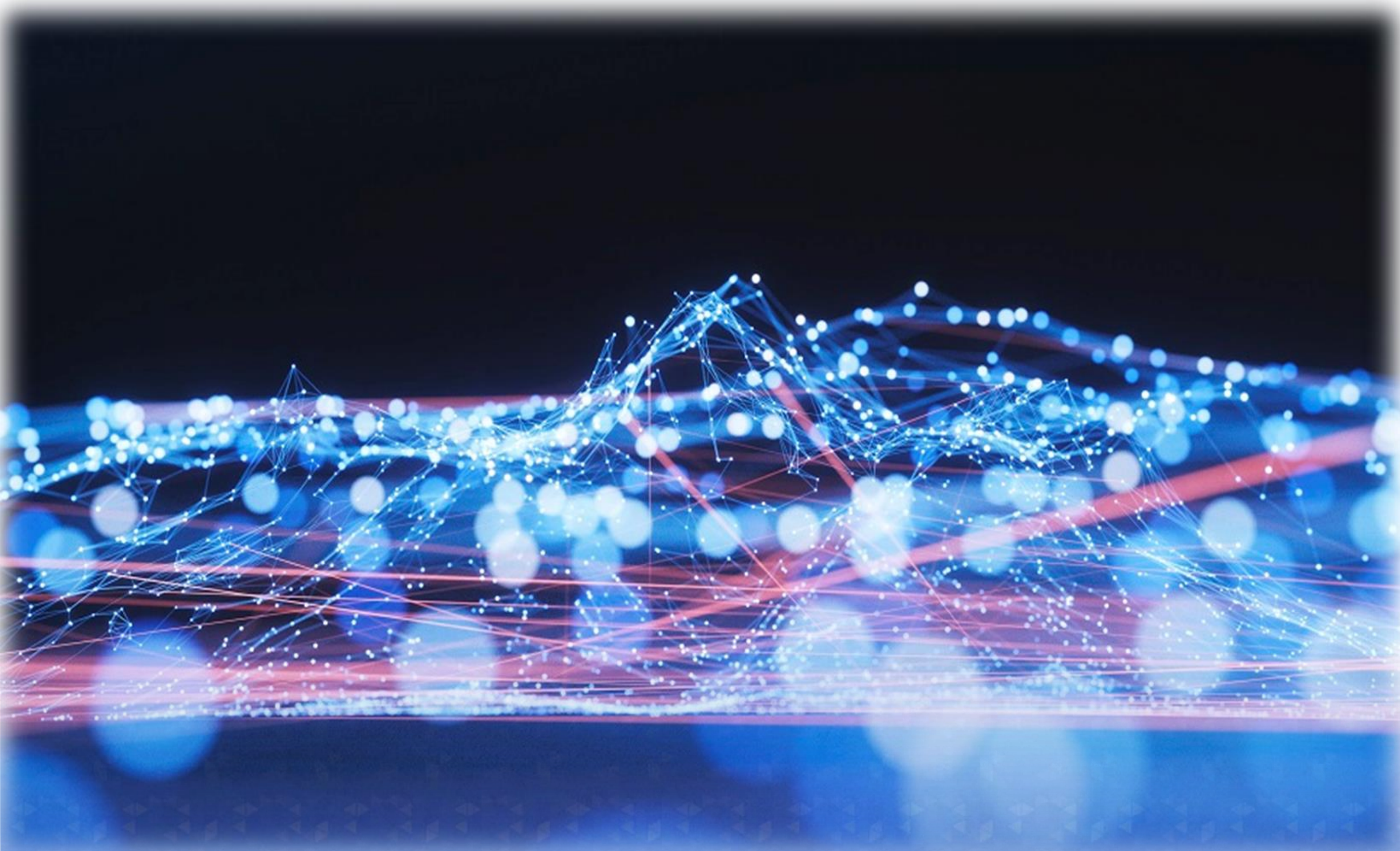

The Operation of Cross-Border Terrestrial Fibre-Optic Networks in Asia and the Pacific

Asia-Pacific Information Superhighway (AP-IS)

Working Paper Series

UNITED NATIONS
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Economic and Social Commission for Asia and the Pacific

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The shaded areas of the map indicate ESCAP members and associate members.

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Executive Summary

Most countries in Asia and the Pacific have built their own fibre-optic backbone networks. Many cross-border terrestrial fibre-optic cable systems have been established between neighbouring countries through bilateral agreements. Yet, this regional network of terrestrial cables is not effectively managed and utilized because of operational challenges.

The interconnection of these dispersed cross-border terrestrial cables will not only increase the capacity of existing transmission channels between countries, especially for landlocked countries, but it will also reduce transit costs, and thus increase Internet affordability for end users. Furthermore, an interconnected terrestrial network will improve the region's Internet speed, quality and reliability.

The cost of this interconnection is relatively small as it will mainly utilize existing domestic telecommunications networks in each country. Yet, there are challenges to achieving the interconnection because of the lack of systems interoperability and the lack of standards or guidelines for charging and accounting settlement of multi-country terrestrial cable circuits, resulting in some countries overcharging for transit services. This is particularly problematic for landlocked countries as they have to pay high charges for access to international networks.

This working paper analyses these challenges and proposes a solution to support the utilization of spare domestic terrestrial cables to carry international cross-border traffic, and enhance the efficiency, affordability and reliability of the regional backbone network.

This working paper begins by describing and analysing five case studies of cross-border terrestrial fibre-optic networks in Asia and the Pacific and in Africa to draw out common challenges found in their operations. The working paper then reviews the operation of submarine cable systems and proposes a solution for the common problems found in the operation of cross-border terrestrial networks, based on the successful operational practices of submarine cable systems and on related literature.

The solution proposed is called the circuit resource sharing mode that includes a cooperation mechanism for all countries involved to construct, operate and maintain the multi-country terrestrial network in a unified manner. A methodology for circuit capacity allocation of the cross-border terrestrial cable system is also proposed as part of this operation mode to address the challenges of charging and accounting settlement.

This working paper aims to contribute to the effective implementation of the Asia-Pacific Information Superhighway (AP-IS), particularly on the interconnections between terrestrial networks in the Asia-Pacific region.

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Abbreviations and Acronyms

AP-IS	Asia-Pacific Information Superhighway
C&MA	Construction and Maintenance Agreement
CA-IS	Central Asia Information Superhighway
CAB	Central African Backbone
EA-IS	East Africa Information Superhighway
ESCAP	Economic and Social Commission for Asia and the Pacific
GMS-IS	Greater Mekong Subregion Information Superhighway
I&ASC	Investment and Agreement Subcommittee
ICT	Information and Communications Technology
II&ASC	Initial Investment and Agreement Subcommittee
IMC	Interim Management Committee
IPG	Initial Procurement Group
ITU	International Telecommunication Union
MC	Management Committee
MIIT	Ministry of Industry and Information Technology (China)
MOU	Memorandum of Understanding
NA/NOC	Network Administration / Network Operation Centre
O&MSC	Operation and Maintenance Subcommittee
PG	Procurement Group
SCO	Shanghai Cooperation Organisation
TASIM	Trans-Eurasian Information Superhighway

Definitions of Key Terms

Operation mode
The methodology for construction, as well as management, maintenance and financial settlement of the cross-border terrestrial fibre-optic cable transmission system.

Optical channel capacity
A parameter of the optical channel that reflects the maximum amount of data the optical channel can transmit.

Wavelength division multiplexing system
A technology that increases transmission capacity by multiplexing optical signals of different wavelengths on a single fibre-optic cable. A fibre-optic transmission network system composed of fibre-optic cables and wavelength division multiplexing devices using the technology is called a wavelength division multiplexing system.

1. Introduction

1.1 Background

Information and communications technology (ICT) interconnections in the Asia-Pacific region have grown remarkably in recent years through national and subregional efforts of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) member States. Yet, there are obvious disparities within the region. ESCAP analyses show that 75 per cent of fixed-broadband subscribers in the Asia-Pacific region come from East and North-East Asia, and China alone accounts for 50 per cent of fixed-broadband subscribers in the region. In the Republic of Korea, there are about 40 fixed-broadband subscribers per 100 inhabitants. At the other end of the spectrum, there are 18 ESCAP member States with less than 2 fixed-broadband subscribers per 100 inhabitants. The digital divide is widening, and if this issue is not addressed, it will adversely affect the ability of the less connected countries to deliver on the United Nations Sustainable Development Goals and the outcomes of the World Summit on the Information Society.

In order to address the unbalanced development of ICT and the widening digital divide in the Asia-Pacific region, the Asia-Pacific Information Superhighway (AP-IS) initiative[1] has been proposed. The AP-IS aims to increase the availability, affordability, resilience and reliability of broadband networks in the region, by strengthening and improving the network infrastructure, and enhancing the interconnection capability of terrestrial and submarine cables. Aware of the urgency and importance of improving regional broadband interconnectivity, member States of ESCAP launched the AP-IS in 2017[2] and endorsed the AP-IS Master Plan 2019-2022[3] and the Regional Cooperation Framework Document 2019-2022[4] in 2019. The AP-IS Master Plan focuses on the implementation of key strategic initiatives under four pillars: (1) connectivity; (2) traffic and network management; (3) e-resilience; and (4) broadband for all. This working paper is one of the strategic initiatives of the AP-IS Master Plan 2019-2022, and will support other activities, such as the development of subregional implementation plans.

The working paper focuses on cross-border terrestrial interconnections under the first

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[1] ESCAP, "Asia-Pacific Information Superhighway". Available at https://www.unescap.org/our-work/ict-disaster-risk-reduction/asia-pacific-information-superhighway.

[2] Official Records of the Economic and Social Council, Seventy-Third Session, Agenda Items 3 (e), Resolution Adopted by ESCAP on 23 May 2017 (E/ESCAP/RES/73/6). Available at http://www.un.org/ga/search/view_doc.asp?symbol=E/ESCAP/RES/73/6.

[3] ESCAP, " Master Plan for the Asia-Pacific Information Superhighway, 2019–2022 ", 1 May 2019. Available at https://www.unescap.org/commission/75/document/E75_INF5E.pdf.

[4] ESCAP, "Asia-Pacific Information Superhighway Regional Cooperation Framework Document, 2019-2022", 1 May 2019. Available at https://www.unescap.org/commission/75/document/E75_INF6E.pdf.

pillar. According to the broadband map produced by the International Telecommunication Union (ITU) and ESCAP,[5] almost all countries in the Asia-Pacific region have fully-achieved or partially-achieved fibre-optic cable network coverage. However, some landlocked countries still face low Internet speed and high transit cost, resulting in low Internet adoption and usage. For example, the per capita Internet bandwidth in Hong Kong, Singapore, Thailand and Viet Nam is more than 100 times higher than the landlocked countries, such as Afghanistan, Lao PDR, Tajikistan and Turkmenistan. One reason is that 95 per cent of the Internet traffic is carried by submarine cables, and landlocked countries lack direct connections to cable landing stations.

The ITU Telecommunication Standardization Sector Study Group 3 is conducting a study similar to this working paper that aims to propose standards and guidelines for tariffs, charging and accounting settlements of cross-border multi-country terrestrial cable circuits. This working paper focuses on supporting the implementation of the AP-IS, particularly in promoting regional interconnectivity and addressing the challenges faced in constructing, operating and maintaining an interconnected terrestrial backbone infrastructure in the Asia-Pacific region.

1.2 Purpose and Methodology

This working paper describes and analyses five case studies of cross-border terrestrial fibre-optic networks implemented by various organizations in Asia and the Pacific and Africa to draw out common problems within and across the regions.[6] The working paper also reviews the operation of submarine cable systems, and proposes a solution for the common problems found in the operation of cross-border terrestrial networks, based on the successful operational practices of submarine cable systems and on related literature. The proposed operation mode for the region's terrestrial backbone intends to reduce overhead costs, improve the management of terrestrial network projects and increase investment attractiveness. From the research findings, this working paper puts forward policy recommendations for the interconnection of the Asia-Pacific regional networks to promote the implementation of the AP-IS.

The next section presents case studies of the following five projects: Greater Mekong Subregion Information Superhighway (GMS-IS); Central Asia Information Superhighway (CA-IS); Trans-Eurasian Information Superhighway (TASIM); Central African Backbone (CAB); and East Africa Information Superhighway (EA-IS). Based on the analysis of these case studies, common problems that exist in the current operation modes of these cross-border terrestrial networks are summarized.

[5] ITU Interactive Terrestrial Transmission/ESCAP Asia-Pacific Information Superhighway Maps. Available at http://www.itu.int/itu-d/tnd-map-public/.

[6] The data and information collated for these case studies are from surveys and communications, which are not publicly available.

Section 3 proposes a solution for the operation of multi-country terrestrial cable networks, with reference to the consortium mode of operation of submarine cable systems around the world and to research results from relevant literature.

Section 4 puts forward policy recommendations for the implementation of the AP-IS, especially in relation to the interconnection of the terrestrial fibre-optic transmission networks in the Asia-Pacific region.

2. Issues and Challenges in the Operation of Cross-Border Terrestrial Networks

This section presents case studies of five cross-border terrestrial fibre-optic network projects, including the GMS-IS, CA-IS and TASIM in the Asia-Pacific region, and CAB and EA-IS in Africa. Based on these case studies, the common problems faced in the operation of these cross-border terrestrial networks are summarized.

2.1 Case Studies of Cross-Border Terrestrial Networks in Asia-Pacific

2.1.1 Case Study 1: Greater Mekong Subregion Information Superhighway

The Greater Mekong Subregion Economic Cooperation was initiated in 1992 with support from the Asian Development Bank, and comprises of six countries – Cambodia, China, Lao PDR, Myanmar, Thailand and Viet Nam. It aims to strengthen economic ties among the six countries, and promote economic and social development in the subregion. To achieve these goals, the construction of a subregional backbone network in the GMS to improve telecommunications linkages is an important part of the cooperation. The six countries established a subregional communications forum to specifically promote cooperation in the field of telecommunications.

In September 2004, the communications authorities of the six countries held a meeting of senior officials in China on the GMS-IS, and the delegations of the six countries agreed to sign a memorandum of understanding (MOU). Subsequently, at the meeting of leaders of the Association of Southeast Asian Nations, China, Japan and the Republic of Korea, held in Lao PDR in November 2004, the representatives of the six countries signed an MOU to jointly promote the construction of GMS-IS.[7]

In January 2005, telecom operators from the six countries held the first meeting of the

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[7] In summary, the MOU states the following: (1) the six countries agree to establish the GMS-IS Steering Group, which is composed of the heads of communications authorities of six countries. The heads of communications authorities of six countries will preside over the Steering Group on a rotating basis. The main tasks of the Steering Group include coordinating the governments of the six countries with respect to polices in developing the GMS-IS, communicating with the Asian Development Bank on relevant issues, evaluating and passing reports of the Implementation Group, and reporting to the six countries; and (2) the six countries agree to establish the GMS-IS Implementation Group, which is composed of representatives of telecom operators from six countries. Representatives of telecom operators from the six countries will preside over the Implementation Group on a rotating basis. The main tasks of the Implementation Group include formulating the GMS-IS construction plan, implementing the GMS-IS construction, dealing with matters related to, among others, funding, technology and personnel training required for the construction of the GMS-IS, and providing a platform for bilateral and multilateral cooperation among telecom operators in various forms from the six countries.

Implementation Group in Kunming, China, and decided to jointly fund and entrust a third-party research institute to prepare the GMS-IS plan. According to this plan, the construction of the GMS-IS project is to be implemented in two phases. The first phase mainly completes the laying of backbone fibre-optic networks and the construction of point-to-point transmission systems. The second phase builds three fibre-optic transmission rings in the GMS.

In May 2005, telecom operators from the six countries held the second meeting of the Implementation Group in Thailand to finalize the plan and agree on an MOU. In July 2005, representatives of telecom operators from the six countries signed the MOU for the construction of GMS-IS at the Greater Mekong Subregion Summit.

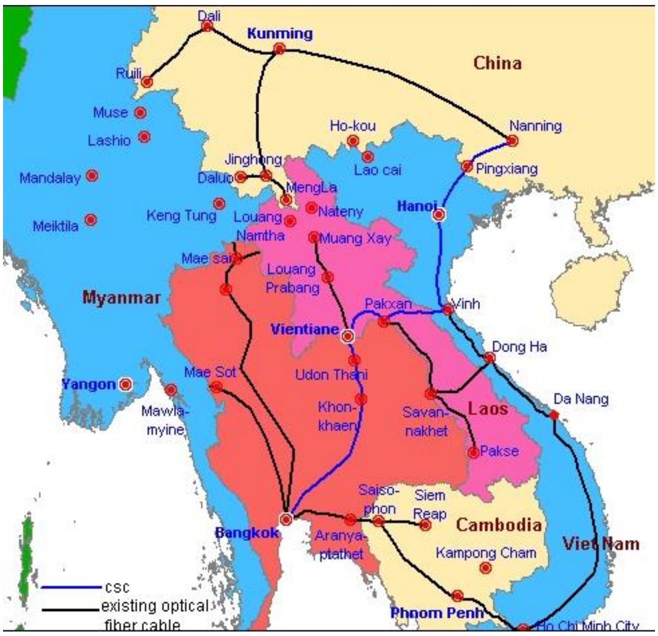
Almost three years later in March 2008, telecom operators from the six countries held a completion ceremony for the first phase of GMS-IS at the Third Greater Mekong Subregion Summit.

Since then, however, the second phase of GMS-IS has not commenced as the countries have failed to reach an agreement on multi-country circuit billing and financial settlement methods, despite various efforts by the governments of the six countries.

Network Planning

Based on an investigation of the backbone fibre-optic network in GMS prior to the implementation of GMS-IS (see Figure 2), the construction of new fibre-optic cable lines was planned to optimize the network architecture and improve connectivity.

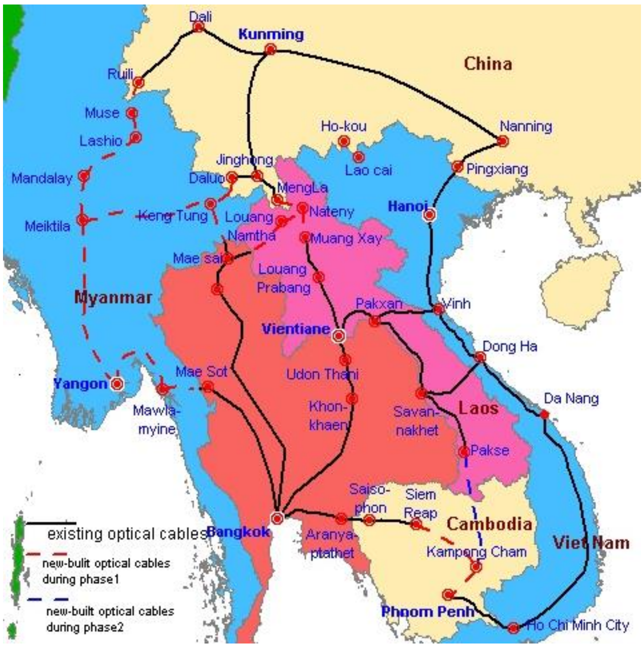
Figure 1: Routing diagram of the backbone fibre-optic networks before Phase 1 of the GMS-IS



Source: CAICT

The GMS-IS plan includes construction of a total of 3,676km new fibre-optic cables – 3,122km in the first phase (indicated in red in Figure 3), and 554km in the second phase (indicated in blue in Figure 3). The target structure of the backbone fibre-optic network for the subregion is shown in Figure 3 (see also Table 1 for details on each planned cable).

Figure 2: Planned construction of additional fibre-optic cables under GMS-IS



Source: CAICT[8]

Table 1: Details of the planned construction of additional fibre-optic cables under GMS-IS

S/N	Fibre-Optic Cable	Type	Length	Remarks
1	Keng Tung (Myanmar) – Da Luo (China)	Cross-border	95km	Myanmar (90km), China (5km)
2	Mengla (China) – Nateny (Lao PDR)	Cross-border	85km	China (50km), Lao PDR (35km)
3	Muse (Myanmar) – Ruili (China)	Cross-border	12km	Myanmar (6km), China (6km)
4	Yangon – Mawlamyine – border between Myanmar and Thailand	Domestic	390km	Myanmar (390km)

[8] Planned construction of new fibre-optic cables in Phase 1 indicated in red, and planned construction of new fibre-optic cables in Phase 2 indicated in blue.

5	Muse – Mandalay – Meiktila – Yangon	Domestic	1,367km	Myanmar (1367km)
6	Meiktila – Keng Tung – border between Myanmar and Thailand	Domestic	626km	Myanmar (626km)
7	Louang Namtha – border between Lao PDR and Thailand	Domestic	200km	Lao PDR (200km)
8	Muang Xay – Nateny – Louang Namtha	Domestic	118km	Lao PDR (118km)
9	Siem Reap – Kampong Cham	Domestic	132km	Cambodia (132km)
10	Kampong Cham – Phnom Penh	Domestic	97km	Cambodia (97km)
	Subtotal in Phase 1	---	**3,122km**	---
1	Pakse (Lao PDR) – Kampong Cham (Cambodia)	Cross-border	554km	Lao PDR (160km) Cambodia (394km)
	Subtotal in Phase 2	---	**554km**	---
	Total	---	**3,676km**	---

Source: CAICT

Principles for Network Planning and Construction

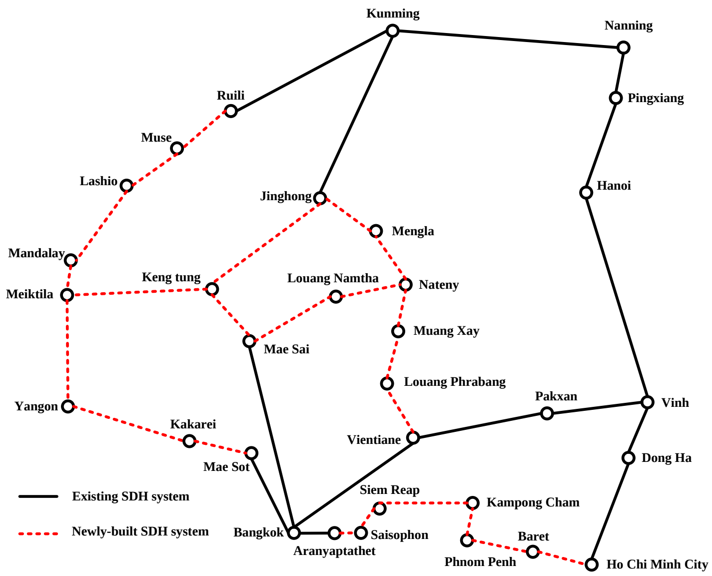
The GMS-IS developed a set of principles to guide its planning and implementation. The principles state that the backbone transmission network of GMS-IS should:

- Meet the demands for telecommunications services in the GMS countries;
- Leverage legacy system resources as much as possible with the aim to bring the best returns on investment and reduce construction costs;
- Adopt a network architecture that is protected on a best-effort basis to ensure the survivability and reliability of service delivery;
- Be scalable to some extent to facilitate network evolution; and
- Be constructed in a phased and gradual way, according to the telecommunications demands of the GMS countries.

Construction Scheme of Phase 1: Point-to-Point Architecture

In the first phase of GMS-IS, the focus was on adding point-to-point transmission systems to improve connectivity in the GMS subregion (see Figure 4 and Table 2). It was envisaged that the construction of 4,434km of point-to-point transmissions (using SDH 2.5Gbps) would significantly increase the capacity of the subregion's backbone fibre-optic network, and GMS countries would be able to achieve transmission speed of up to 155Mbps.

Figure 3: Network architecture of the point-to-point fibre-optic systems in GMS-IS Phase 1



Source: CAICT

Table 2: Newly-built point-to-point system of backbone fibre-optic network in GMS-IS Phase 1

S/N	Point-to-Point System	Type	Length	Remarks
1	Keng Tung – Da Luo – Jinghong	Cross-Border	219km	Myanmar (90km), China (129km)
2	Muse – Ruili	Cross-Border	12km	Myanmar (6km), China (6km)
3	Keng Tung – Tachileik – Mae Sai	Cross-Border	145km	Myanmar (137km), Thailand (8km)
4	Kakarei – Mae Sot	Cross-Border	75km	Myanmar (67km), Thailand (8km)
5	Jinghong – Mengla – Nateny	Cross-Border	231km	China (196km), Lao PDR (35km)
6	Louang Namtha – Mae Sai	Cross-Border	321km	Lao PDR (200km), Thailand (121km)
7	Aranyaptathet – Poipet	Cross-Border	9km	Thailand (8km), Cambodia(1km)
8	Bavet – Ho Chi Minh City	Cross-Border	78km	Cambodia (1km), Viet Nam (77km)
---	**Subtotal of cross-border segments**	---	**1,090km**	---
9	Muse – Lashio – Mandalay	Domestic	690km	Myanmar (690km)
10	Yangon – Kakarei	Domestic	323km	Myanmar (323km)
11	Louang Namtha – Nateny – Muang Xay – Louang Phrabang – Vientiane	Domestic	600km	Lao PDR (600km)

12	Poipet – Saisophon – Siem Reap – Kampong Cham – Phnom Penh – Bavet	Domestic	565km	Cambodia (565km)
13	Yangon – Mandalay	Domestic	677km	Myanmar (677km)
14	Meiktila – Keng Tung	Domestic	489km	Myanmar (489km)
---	**Subtotal of domestic segments**	**---**	**3,344km**	**---**
---	**Total**	**---**	**4,434km**	**---**

Source: CAICT

Construction Scheme of Phase 2: Ring Architecture

The plan for the second phase is to introduce a ring architecture to the GMS backbone fibre-optic network. Three interconnected rings are to be built, with an architecture that overlaps the point-to-point architecture built in Phase 1. Through unified networking, construction, management, and operation and maintenance, it is envisaged that the networks in the GMS subregion will be interconnected and interoperable, thus significantly improve the efficiency of cross-border circuit deployment and network operation among the GMS countries.

GMS-IS Project Operation Mode and Problem Analysis

Phase 1: Independent Construction, Operation and Maintenance

In the first phase, each of the cross-border point-to-point system has been built through negotiations between telecom operators of the two respective neighbouring countries. However, in the bilateral negotiations, the networking requirements and circuit scheduling of other systems in the entire network are not considered. This practice has resulted in systems operating independently of each other. This operation mode called independent construction, operation and maintenance has five main problems, which are outlined in Table 3. Figure 5 depicts the characteristics of this operation mode.

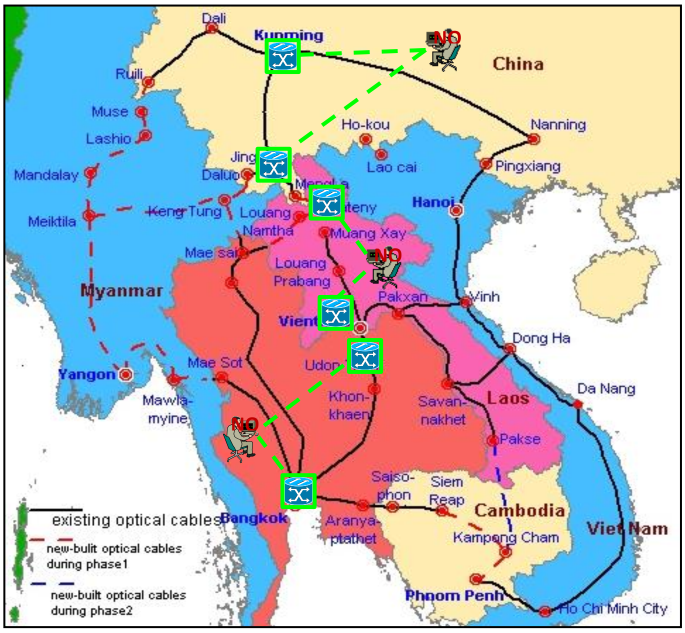
Table 3: Problems with the independent operation mode of GMS-IS Phase 1

Problem 1	The point-to-point transmission systems are built by different manufacturers using different equipment standards, which make it impossible to create a unified and interoperable subregional network.
Problem 2	Although GMS countries have built fibre-optic cables that are physically connected to each other, the transmission networks of the six countries operate separately.
Problem 3	Telecom operators need to manually configure their domestic networks, and then use fibre-optic or digital wiring frame between two cross-

	border sections, which is time-consuming and inefficient.
Problem 4	As there are no unified criteria and principles, the agreement on the settlement rate for each cross-border point-to-point system needs to be separately negotiated by the two respective neighbouring countries, which is time-consuming, and often countries are unable to reach an agreement.
Problem 5	The potential of the entire fibre-optic network to interconnect the GMS is not fully utilized since only the successfully-negotiated cross-border transmission systems between neighbouring countries are interoperable.

Source: CAICT

Figure 4: Operation mode of GMS-IS Phase 1 – independent construction, operation and maintenance



Source: CAICT

Phase 2: Unified Construction, Operation and Maintenance

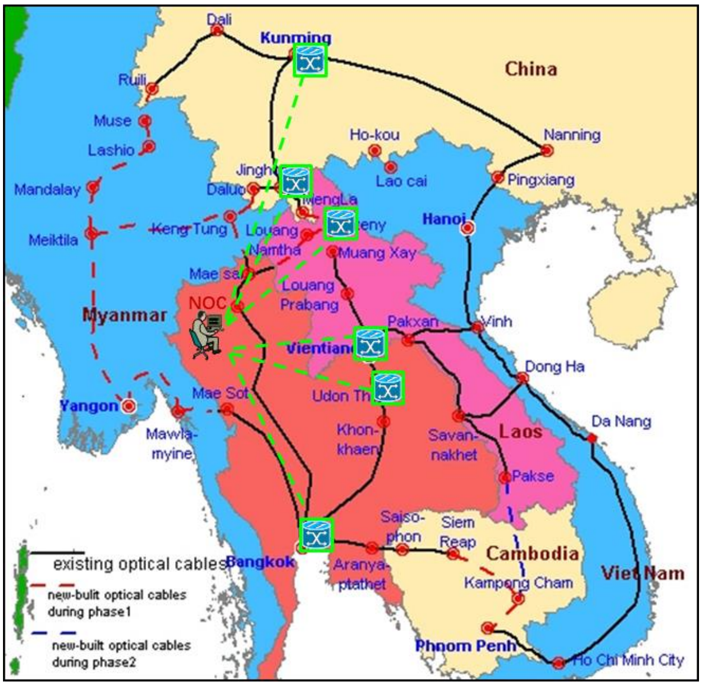
The plan for the second phase of GMS-IS is to build three interconnected ring network transmission systems to allow interoperability between the rings. The ring network architecture requires a unified mode of construction, operation and maintenance, which means that the equipment used in the rings must have the same technical standards, and the network systems need to be managed in an integrated manner among the GMS countries. The advantages of the unified operation model are given in Table 4, and Figure 6 depicts the characteristics of this operation mode.

Table 4: Advantages of the unified operation mode of GMS-IS Phase 2

Advantage 1	Changes to network configurations across multiple countries can be applied automatically in a unified network management system, saving time and improving efficiency.
Advantage 2	The potential of the entire fibre-optic network can be fully exploited to significantly improve the interconnection of the six GMS countries.

Source: CAICT

Figure 5: Operation mode of GMS-IS Phase 2 – unified construction, operation and maintenance



Source: CAICT

Despite the advantages, the second phase of GMS-IS is still pending implementation, mainly because the GMS countries have yet to reach an agreement on the mechanisms for unified construction, operation and maintenance. However, even with a unified mode of construction, operation and maintenance in place, it will only solve problems 1, 3 and 5 listed in Table 3. Resolving problem 4 (charging and accounting settlement for circuits across multiple countries) is the key, because the solution to problem 2 (country cooperation in construction, operation and maintenance) is directly related to problem 4. In fact, at the Fifth Meeting of the Steering Group of GMS-IS held in Cambodia in 2009, the countries in the subregion agreed that the mechanisms for charging and accounting settlement across multiple countries should be resolved first before commencing Phase 2 of GMS-IS.

2.1.2 Case Study 2: Central Asia Information Superhighway

The CA-IS is an initiative of the Shanghai Cooperation Organisation (SCO), an intergovernmental organization founded on 15 June 2001 by the leaders of six countries – China, Kazakhstan, Kyrgyzstan, Russia, Tajikistan and Uzbekistan. The CA-IS aims to strengthen the ICT infrastructure of the six countries, promote close cooperation in the ICT sector and drive economic development.

In March 2007, the First Meeting of the CA-IS Expert Group was held in Bishkek, Kyrgyzstan and was participated by ministers of communications in the six countries. A third-party research institute presented the CA-IS project to the ministers in light of findings from a research study conducted. In September 2008, at the Fourth Meeting of the CA-IS Expert Group in Yekaterinburg, Russia, ministers reviewed the materials of the CA-IS project and adopted relevant resolutions.[9]

In December 2008, at a meeting of the CA-IS Implementation Group held in Sanya, China, telecom operators from all six countries agreed on a detailed road map for network construction. Then in October 2010, at the Fifth Meeting of the Expert Group of CA-IS held in Beijing, China, a research study on planning of the CA-IS was presented. The report clarified the concerns of relevant countries on issues related to pricing policies and financial settlement principles for cross-border transfers and services for end users.

To date, the first phase of CA-IS has been completed, but the six countries have not yet reached an agreement on the construction scheme, especially the pricing policies and financial settlement principles for cross-border transfer and services for end users, despite a long period of discussions. As a result, project activities after the first phase of CA-IS have mainly been bilateral cooperations between telecom operators of the countries. The second phase of CA-IS is still pending commencement.

Network Planning

According to the CA-IS project plan, implementation is in two phases. The first phase involves the construction of the China – Kyrgyzstan – Uzbekistan and the Uzbekistan – Kazakhstan sections of the fibre-optic cable system, and builds the north and south SDH ring networks. The second phase involves the laying of fibre-optic cable in the Tajikistan – Kyrgyzstan section and builds the SDH sub-ring network, as shown in Table 5.

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9 In summary, the resolutions include the following: (1) submission of proposals on the economic mode (business model) of project implementation by the member States to the Expert Group and the Project Coordinator, covering – firstly, the cooperative principles between telecom operators in the project construction stage and in the use of project resources; and secondly, the pricing policies and financial settlement principles for cross-border transfers and services for end users; and (2) proposal from Russia to the Expert Group and the Project Coordinator on expanding the Western Ring in the Caspian Sea region and involving SCO observer countries in the CA-IS project.

Table 5: CA-IS project schedule

	Work	Scale
Phase 1	Cable System: Kashgar (China) – Osh (Kyrgyzstan) – Andijan (Uzbekistan)	24-core G.652 fibre-optic cable, 565km
	Cable System: Kungrad (Uzbekistan) – Beineu (Kazakhstan)	12-core G.652 fibre-optic cable, 435km
	Cable System: (Ukraine) – Denau (Uzbekistan) – Tursunzade (Tajikistan) – Dushanbe (Tajikistan)	12-core G.652 fibre-optic cable, 100km
	Cable System: Samara (Russia) – Oral (Kazakhstan)	12-core G.652 fibre-optic cable, 300km
	North SDH Ring: Almaty – Astana – Samara – Atelau – Tashkent – Almaty	7,760 system kilometres, 2.5Gbps ADM: 5 sets
	South SDH Ring: Urumqi – Almaty – Bishkek – Tashkent – Andijan – Osh – Kashgar – Urumqi	5,150 system kilometres, 2.5Gbps ADM: 7 sets
Phase 2	Cable System: Dushanbe (Tajikistan) – Sary-Tash (Kyrgyzstan)	24-core G.652 fibre-optic cable, 535km
	Sub-Ring: Dushanbe – Osh – Tashkent – Dushanbe	3,195 system kilometres, 2.5Gbps ADM: 3 sets
	Upgrade of North and South Rings	Line rate upgraded to 10Gbps

Source: CAICT

Principles for Network Planning and Construction

The CA-IS developed a set of principles to guide its planning and implementation. It was agreed that the government of each member country designates at least one telecoms operator to participate in the project. The governments are responsible for developing relevant national policies for the construction of the CA-IS, communicating and cooperating with relevant international organizations, and facilitating cooperation among telecom operators to ensure smooth implementation.

The telecom operators participating in the project are responsible for network construction in their respective countries. This includes formulating network construction plans and addressing issues related to funding, technology, human resources and training required for the construction of the CA-IS. Additionally, the telecom operators are responsible for network interconnection at border-crossing sections, which involves coordinating construction timing and equipment specifications with neighbouring countries to ensure network interoperability. The participating telecom operators are also expected to operate and maintain the built networks.

The principles for network planning and construction state that the backbone transmission network of CA-IS should:

- Cover the major cities in the six countries;
- Leverage existing system resources to reduce construction costs, such as existing fibre-optic cable routes and existing dense wavelength division multiplexing systems;
- Reduce transmission detours, and where possible, establish direct fibre-optic cable routes between neighbouring countries;
- Ensure the security and reliability of the regional backbone networks;
- Be scalable so that future networks can cover the observer countries of SCO (such as Azerbaijan, India, Iran, Mongolia, Pakistan, Turkmenistan and other countries); and
- Be constructed in a phased and gradual way, according to the telecommunications demands of the six countries.

Construction Scheme of Phase 1: Basic Fibre-Optic Cable Networks

Phase 1 has been constructed according to the principles stated above, which includes coverage of the major cities, fully utilizing existing domestic fibre-optic cables, establishing the shortest routes, and identifying the most economical option for building new fibre-optic cables. The route of the CA-IS fibre-optic networks in Phase 1 is shown in Figure 7.

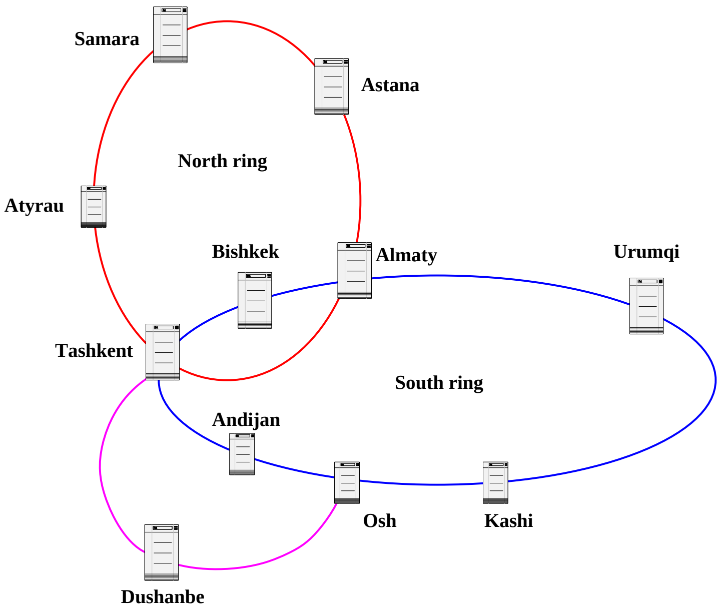
Figure 6: Routing diagram of the fibre-optic networks in CA-IS Phase 1

Source: CAICT

Construction Scheme of Phase 2: Ring Transmission Networks

Based on the architecture of the basic fibre-optic networks, Phase 2 that has yet to be implemented, will construct the north and south 2.5Gbps SDH ring networks and a 2.5Gbps SDH sub-ring (see Figure 8). The 2.5Gbps SDH equipment in the north and south rings can be upgraded smoothly to a speed of 10Gbps. The north and south rings are interconnected in Almaty and Tashkent to achieve circuit scheduling between the two rings, and the sub-ring is mainly used to channel Dushanbe's circuits and is interconnected with the south ring in Osh and Tashkent.

Figure 7: Diagram of the ring transmission networks in CA-IS Phase 2



Source: CAICT

CA-IS Project Operation Mode and Problem Analysis

Phase 1: Independent Construction, Operation and Maintenance

Phase 1 of the CA-IS mainly constructed the cross-border fibre-optic cables between China, Kyrgyzstan and Uzbekistan. Similar to Phase 1 of the GMS-IS, the transmission network uses a point-to-point architecture that relies on negotiations between telecom operators of the respective neighbouring countries on the transit charges and settlement rate for cross-border circuits. With this operation mode, the cross-border terrestrial fibre-optic transmission system is made up of multiple independent operations that do not interconnect.

Phase 2: Unified Construction, Operation and Maintenance

The plan for the second phase of CA-IS is similar to the second phase of GMS-IS. The ring network architecture requires a unified mode of construction, operation and maintenance, which means that the equipment used in the rings must have the same technical standards, and the network systems need to be managed in an integrated manner among the participating countries.

The SCO Working Group has held four meetings to discuss the implementation of the CA-IS project, but the second phase of CA-IS is still pending implementation. This is because the participating countries have not been able to reach an agreement on the mechanisms for cross-border use of resources, and for charging and accounting settlement across multiple countries. Some countries have emphasized the need to address these issues prior to the implementation of the second phase. Moreover, Russia has proposed the involvement of SCO observer countries in the CA-IS project. But a cooperative agreement among the existing six countries needs to be successfully established first before expanding the project and involving other participants.

2.1.3 Case Study 3: Trans-Eurasian Information Superhighway

In 2008, at the Fourteenth Azerbaijan International Telecommunication and Information Technologies Exhibition and Conference, the Azerbaijan government officially introduced the TASIM initiative and released the Baku Declaration to implement the TASIM project. The TASIM project aims to create a transnational terrestrial fibre-optic backbone from Western Europe to Eastern Asia to improve regional and global connectivity and network resilience, meet the increasing demands for communications, computing, consumer electronics and media, and narrow the digital divide. This initiative has attracted attention and support from the United Nations and relevant countries.

According to the TASIM project document, a terrestrial fibre-optic cable system is to be built from Frankfurt in Western Europe to Hong Kong in East Asia. The cable system will run through Germany, Austria, Hungary, Bulgaria, Turkey, Georgia, Azerbaijan, Kazakhstan and China, with a total length of about 11,000km and a capacity of tens of terabytes. The cable system will mainly be built and jointly operated by telecom operators from Azerbaijan, China, Germany, Kazakhstan, Russia and Turkey.

Many of the countries involved in the TASIM project are landlocked and have limited regional and global connectivity since they do not have direct access to submarine cable landing stations and have to rely on the limited cross-border terrestrial connections. Landlocked countries have difficulties accessing sufficient international bandwidth due to high transit costs, but with the implementation of TASIM, it is expected that landlocked countries will have greater and better quality access to regional and international connectivity at lower costs, thus enhancing the capability of these countries to access the Internet and use various applications.

Since the Azerbaijan government proposed the project in 2008, the Ministry of Communications and Information Technologies of Azerbaijan established and funded the TASIM Executive Group in 2010, which is responsible for consultation and cooperation with telecom operators in participating countries. In 2011, Azerbaijan called the first TASIM International Seminar, which was participated by telecom operators from all the project countries. At the seminar, a Project Secretariat was established and the telecom operators agreed to work towards an MOU to establish the TASIM Consortium. In December 2013, the International Relations and Accounting Centre of Azerbaijan, China Telecom (China), KazTransCom (Kazakhstan), Rostelecom (Russia) and Türk Telekom (Turkey) signed a preliminary agreement of intent to establish the TASIM Consortium. In September 2017, at a meeting of the TASIM Working Group held in Almaty, Kazakhstan, the telecom operators decided to jointly fund a third-party research institution to conduct a feasibility study for the implementation of the TASIM project.

It has been over a decade since the TASIM project was first proposed and to date, the feasibility study is still being conducted. The main reasons for the slow progress is the lack of internationally-accepted criteria or guidelines for charging and accounting settlement of multi-country terrestrial cable circuits, and the lack of a fair and appropriate operation mode, resulting in some intermediary countries overcharging for transit cable services.

2.2 Case Studies of Cross-Border Terrestrial Networks in Other Regions

2.2.1 Case Study 4: Central African Backbone

In May 2007, at the Summit of the Economic and Monetary Community of Central

Africa held in N'Djamena, the heads of Central African countries adopted a joint declaration calling for the implementation of a broadband fibre-optic network in Central Africa. The CAB project aims to construct a cross-border terrestrial fibre-optic cable infrastructure and enhance regional integration. The countries included in the CAB project are Cameroon, the Central African Republic, Chad, Democratic Republic of the Congo, Gabon, Principe, Republic of the Congo and Sao Tome. According to the CAB project document, the project has five phases with each phase focusing on the fibre roll out in one or more countries.

The project was officially launched in September 2009 and is scheduled to be completed in December 2019. The project is funded mainly by World Bank loans, with investment initially estimated at USD160 million. As of 2015, World Bank had provided USD206 million to the project and the total cost of the project (including funds from sources other than the World Bank) was estimated to be USD273 million.

The pilot phase of CAB involved three countries – Cameroon, the Central African Republic and Chad. Initially, the World Bank proposed the establishment of a supranational telecom operator for the three countries to deploy and manage the cross-border fibre-optic infrastructure at the subregional level. This was to ensure at least two cross-border network interconnection points between the different Central African countries.

In the implementation of the project, however, the model anticipated by the World Bank was not successful as each country wanted to have its own operator to build and operate the backbone fibre-optic network within its territory. As a result, bilateral cooperation was adopted in the process. Under the mode of bilateral cooperation, the CAB was only able to establish connectivity between each two neighbouring countries, but failed to realize network interconnection among all the countries in the Central African region. The problem of high transit costs for landlocked countries remains unresolved.

Similar to the Asia-Pacific case studies, the main reasons for not implementing a multiparty cooperation mode is the lack of a set of principles for multi-country cooperation, and the lack of criteria or guidelines for charging and accounting settlement of multi-country terrestrial cable circuits.

2.2.2 Case Study 5: East Africa Information Superhighway

In June 2015, China's Ministry of Industry and Information Technology (MIIT), ITU and five East African countries (Burundi, Kenya, Rwanda, Tanzania and Uganda) jointly held the East African Information and Communications Infrastructure Development Forum in Dar es Salaam, Tanzania. The ministers of the countries that attended the forum reached consensus to jointly implement the Broadband East Africa Project.

Subsequently in December 2015, during the Johannesburg Summit of the Sino-Africa Cooperation Forum, MIIT, ITU and the five East African countries signed an MOU on accelerating cooperation in ICT infrastructure construction in East Africa, which included the implementation of the EA-IS project.

In 2017, ITU and MIIT, among others, organized a joint research group and visited the five East African countries. During the visits, the countries reiterated the need for regional cross-border terrestrial interconnection, and requested for support from ITU and China in the implementation of the EA-IS. The EA-IS aims to improve network reliability, reduce transit charges and meet the urgent demand for broadband connectivity in East African countries.

According to the initial plan of the EA-IS, the project is to be implemented in two phases. The first phase is to build a fibre-optic ring network across Rwanda, Uganda and Tanzania, and the second phase is to build a fibre-optic ring network connecting the five East African countries and a submarine cable transmission system.

Based on a report by the joint research group in 2017, point-to-point transmission systems have been bilaterally constructed among Rwanda, Uganda and Tanzania, i.e., one fibre-optic cable route between each neighbouring country without any protection and backup. The report indicates that the systems are very unstable and often break down, and there is an urgent need to build a ring network to interconnect the three countries. Consequently, the three countries have signed an agreement to build a fibre-optic ring network.

However, construction of the ring network across the three countries have been delayed due to lack of relevant technologies, funds and standards, especially the lack of standards or guidelines for charging and accounting settlement of multi-country terrestrial cable circuits. A key issue that needs to be addressed is the high transit charges collected by intermediary countries. This is particularly problematic for landlocked countries that need to incur transit costs for access to submarine cable systems. For example, for the international network connection from Kigali, Rwanda (a landlocked country) to Mombasa, Kenya and then to the UK, the distance from Kigali to Mombasa is only one sixth of the distance from Mombasa to the UK, but the charge for the former is 10 times that of the latter.

2.3 Common Problems in the Operation of Cross-Border Terrestrial Networks

From the analysis of the case studies in Sections 2.1 and 2.2, some common problems in the operation of cross-border terrestrial networks have been identified. Firstly, most of the existing cross-border terrestrial systems have adopted the independent mode of construction, operation and maintenance, which results in the following problems:

- **Unified networking is impossible** – The transmission network uses a point-to-point architecture that relies on bilateral negotiations between telecom operators of the neighbouring countries. This practice has resulted in systems operating independently of each other because the point-to-point transmission systems within a regional network are built using different technical standards, which make it impossible for countries to interconnect their systems.

- **In multi-country negotiations, no agreement can be reached** – As there are no internationally-accepted criteria or guidelines that could establish fair interconnections between multiple countries, multi-country cooperation initiatives are often stalled since an agreement cannot be reached, particularly when it comes to setting transit charges and settlement rates for cross-border circuits. As a result, countries have turned to bilateral negotiations in order to reach agreements on the settlement of circuit charges. However, bilateral negotiations are not only inefficient and time-consuming, they may also lead to high transit charges, especially for landlocked countries.

- **The utilization of network resources is low** – The cross-border fibre-optic networks that have been built across regions are only effectively utilized between neighbouring countries, since only the successfully-negotiated cross-border transmission systems are interoperable. Large quantities of spare domestic terrestrial cables fail to be utilized for carrying international traffic.

Secondly, the unified mode of construction, operation and maintenance of cross-border terrestrial fibre-optic cable systems requires that the equipment used are interoperable, and the network systems need to be managed in an integrated manner among the participating countries. This unified mode can solve some of the problems of the independent mode described above.

In practice, however, cross-border terrestrial fibre-optic cable projects have not been able to successfully adopt the unified mode of construction, operation and maintenance. This is mainly due to the lack of a cooperation mechanism for multi-country terrestrial networks, and the absence of internationally-accepted guidelines or criteria for setting transit charges and settlement rates for cross-border circuits. As a result, some landlocked countries are facing enormous difficulties in connecting and accessing the Internet mainly due to the high transit charges imposed by intermediary countries.

In summary, the problem analysis reveals the following key problems in the operation of cross-border terrestrial fibre-optic cable systems:

- In terms of management, there is no effective cooperation mechanism for managing cross-border terrestrial fibre-optic cable projects across multiple (three or more) countries; and

- In terms of settlement, there is an absence of fair and reasonable criteria for the allocation of multilateral terrestrial fibre-optic cable circuit resources and payment, resulting in the failure to reach a consensus among countries involved in the construction and operation of the cross-border terrestrial network.

3. Solution for the Operation of Cross-Border Terrestrial Networks

This section begins by examining an operation mode of submarine cable networks around the world, and compares it with the operation modes of cross-border terrestrial networks. This is followed by a proposed solution for the common problems found in the operation of cross-border terrestrial networks (identified in Section 2.3), based on the successful practices in operating submarine cable systems and on related literature.

3.1 Operation Mode of Submarine Cable Networks

The most common operation mode for submarine cable network projects is the consortium mode. In this mode, submarine cables are jointly funded, planned, designed, built and run by telecom operators from different countries sharing the same purpose. The group of telecom operators interested in capacity along a particular cable route, pool their resources to build the cable, then share capacity. Each member of the consortium is allocated units of capacity according to the investment amount. Members of the consortium also jointly operate and maintain the cable network.

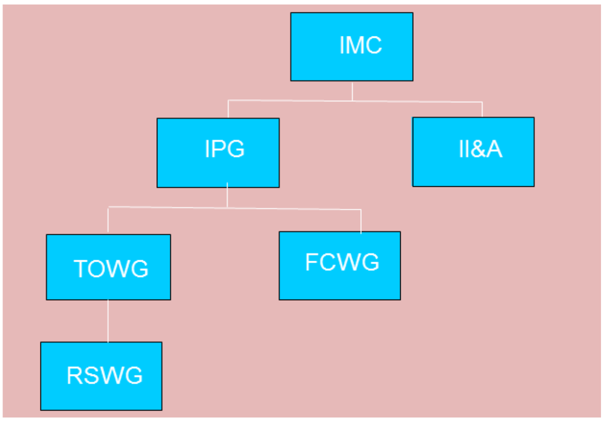
The consortium mode can be divided into four stages as follows:

1. Initiation stage – From project conceptualization to MOU signing;
2. Bidding, and construction and maintenance agreement (C&MA) signing stage;
3. Construction or contract execution stage; and
4. Operation and maintenance stage.

Among them, the second and third stages are very important. In the bidding and C&MA signing stage, there are various external and internal activities. External activities include the establishment of the organizational structure, implementation of activities according to the MOU, and signing of the C&MA and the general contract. Internal activities include conducting a feasibility study and project approval, application for permission to construct landing stations, and internal project approval of operators and ancillary equipment requirements of the landing stations.

The establishment of the organizational structure is a key activity in the second stage so that cable construction can begin as soon as possible. A sample organizational structure for this stage is given in Figure 11, which is likely to include an Interim Management Committee, Interim Procurement Group, and Interim Investment and Agreement Subcommittee.

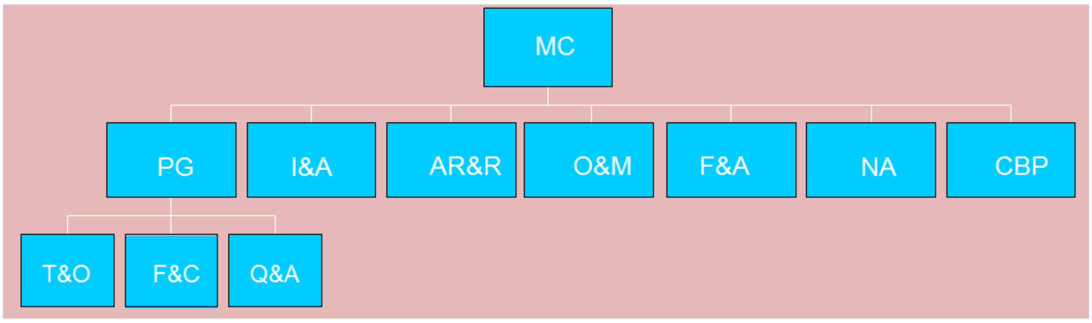
Figure 8: Organizational structure in the bidding and C&MA signing stage



Notes: IMC = Interim Management Committee; IPG = Interim Procurement Group; II&A = Interim Investment and Agreement Subcommittee; TOWG=Technique and Operations Working Group; FCWG=Financial and Contractual Working Group; and RSWG=Route Survey Working Group.

In the construction stage, the key activities are to set up the organizational structure specified in the C&MA and carry out the construction works in accordance with the signed agreement. A sample organizational structure for this stage is given in Figure 12, which is likely to include the Project Management Committee that oversees the submarine cable project with the assistance of various subcommittees and groups, including the Procurement Group, Investment and Agreement Subcommittee, Opening and Recovery Subcommittee, Operation and Maintenance Subcommittee, Finance and Accounting Subcommittee, and Network Administration Centre.

Figure 9: Organizational structure in the construction stage



Notes: MC = Management Committee; PG = Procurement Group; I&A = Investment and Agreement Subcommittee; AR&R = Assignments, Routing and Restoration Subcommittee; O&M = Operations and Maintenance Subcommittee; F&A = Financial and Administrative Subcommittee; NA = Network Administrator Center; CBP=Central Billing Party; T&O=Technique and Operations Group; F&C=Financial and Contractual Group; Q&A=Quality and Assurance Group.

In the consortium mode, each telecom operator has a representative in the Project Management Committee, which is generally responsible for the overall management of the submarine cable project. This includes completing the design, bidding process and bid evaluation, and formulating various policies on project operations and management. In this mode, each member of the consortium is responsible for the application for landing license, extension and connection. Each member shares the bandwidth resources and other rights of the submarine cable system according to the proportion of investment. Each member also contributes to operation and maintenance expenses according to the proportion of investment.

3.2 Comparison of Cross-Border Terrestrial and Submarine Network Operations

At present, the consortium mode used to operate the submarine cable systems is relatively mature with the following advantages:

- The Project Management Committee is comprised of representatives designated by telecom operators from different countries sharing the same purpose. This committee provides a mechanism for members of the consortium to communicate and coordinate the various needs of different countries. The allocation of voting rights in major decisions is in proportion to the investment made.

- There is no circuit transit costs as network capacity is allocated according to the proportion of investment made. Additionally, legal procedures are less complex since the deployment of submarine cables takes place mainly in the high seas.

Cross-border terrestrial network projects can learn from the effective cooperation mechanism used by submarine network consortiums. However, cross-border terrestrial network projects are made up of existing domestic terrestrial cable networks, and thus, requires negotiation among participating countries on the allocation of network capacity and on the criteria for financial settlement.

3.3 Circuit Resource Sharing Mode of Operation: A Proposed Solution

Based on the common problems identified in Section 2.3 and the good practices from submarine cable network projects discussed in Section 3.1, this subsection proposes a solution for the operation of cross-border terrestrial networks called the circuit resource sharing mode. The organizational structure for the management of cross-border terrestrial networks and a method for the allocation of cable capacity for financial settlement in this operation mode are presented below.

3.3.1 Management and Cooperation Mechanism

In the circuit resource sharing mode, a cross-border terrestrial network is constructed, shared, operated and maintained by all participants. Therefore, it is necessary to establish a cooperation mechanism involving all participants to achieve unified standards for transmission equipment, network management, and operation and maintenance.

In the circuit resource sharing mode, a Project Management Committee is formed with representatives from each participating organization to manage the different stages of the project. Different organizational structures are established and corresponding functions are assigned for the MOU signing stage, and for the construction and operation stage (see Figure 13).

At the MOU signing stage, the establishment of the Interim Management Committee (IMC), Initial Procurement Group (IPG) and Initial Investment and Agreement Subcommittee (II&ASC) is proposed with the following functions:

- IMC will be responsible for the overall coordination of the MOU signing stage;

- IPG will collect up-to-date technical information and formulate supply contracts; and

- II&ASC will raise funds, execute network construction, formulate management rules on operation and maintenance, and draft the C&MA.

At the construction and operation stage, the establishment of the Management Committee (MC), Procurement Group (PG), Investment and Agreement Subcommittee (I&ASC), Operation and Maintenance Subcommittee (O&MSC) and Network Administration/Network Operation Centre (NA/NOC) is proposed with the following functions:

- MC will be responsible for the overall coordination of the construction and operation stage;

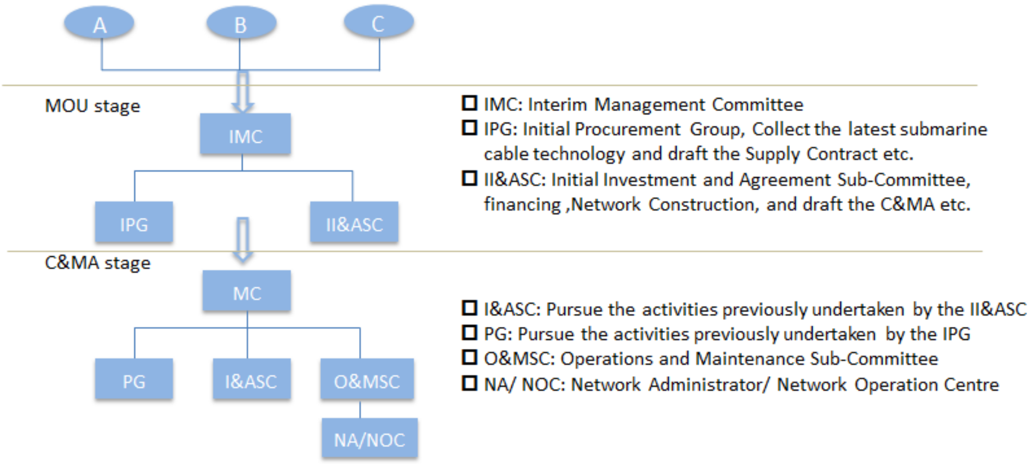
- PG will continue the functions of the IPG, and will be responsible for negotiation with suppliers, and deciding on the purchase prices and project acceptance;

- I&ASC will continue the functions of the II&ASC;

- O&MSC will be responsible for allocating and coordinating the duties of participants in network operation and maintenance; and

- NA/NOC, under the O&MSC, will monitor the entire network, manage network configuration and allocate maintenance tasks to participants.

Figure 10: Organizational structure in circuit resource sharing mode for cross-border terrestrial networks



3.3.2 Allocation of Circuit Capacity for Financial Settlement

In the circuit resource sharing mode, the circuit capacity allocation of the cross-border terrestrial cable system is determined by the designated channel capacity of the end-to-end cross-border terrestrial cable transmission wavelength division systems in proportion to the physical length of the fibre-optic cables provided by each participant.

This method of allocation is explained with the following example: Assume countries A, B, C and D participating in building the A-B-C-D route of a cross-border terrestrial cable, where the physical length of A's fibre-optic cable is 1,600km, B's cable is 600km, C's cable is 1,000km, and D's cable is 800km. According to the allocation method in the circuit resource sharing mode for cross-border terrestrial cable, the channel capacity of cross-border terrestrial cable system allocated to participants A, B, C and D of the A-B-C-D cross-border terrestrial cable routing section is shown in Table 6.

Table 6: Channel capacity allocated to participants A, B, C and D of the A-B-C-D routing section

Participants	Whole End-to-End Wavelength Division System (A-B-C-D)		
	Physical Length of Fibre-Optic Cable (km)	Percentage (%)	Channel capacity (n*100G)
A	1,600	40	32
B	600	15	12
C	1,000	25	20
D	800	20	16
Total	**4,000**	**100**	**80**

4. Recommendations for the Implementation of the AP-IS

As one of the four pillars of the AP-IS, interconnectivity plays an important role in developing a seamless broadband network infrastructure in the Asia-Pacific region that is affordable, reliant, resilient and accessible to all. This will contribute to the narrowing of the regional digital divide and support sustainable economic and social development in the Asia-Pacific region.

The circuit resource sharing mode of operation for cross-border terrestrial networks proposed in Section 3.3 is expected to play an important role in promoting win-win multilateral cooperation to interconnect the Asia-Pacific region if it is adopted and promoted by member States on the AP-IS platform.

In light of the AP-IS Master Plan and the Regional Cooperation Framework, two key recommendations are proposed to promote the circuit resource sharing mode of operation for cross-border terrestrial networks in the Asia-Pacific region in order to facilitate the implementation of the AP-IS.

4.1 Recommendation 1: Draft a Resolution to Encourage Member States to Adopt the Circuit Resource Sharing Mode of Operation for Cross-Border Terrestrial Networks in the Asia-Pacific Region

Draft a resolution for member States to adopt the resource sharing mode of operation for cross-border terrestrial networks in the Asia-Pacific region, including the management and cooperation mechanism, and the method for the allocation of circuit capacity for financial settlement. Facilitate a discussion at the next AP-IS Steering Committee Meeting on the draft resolution and submit the draft resolution at the next Commission Session of ESCAP to solicit comments from member States.

4.2. Recommendation 2: Incorporate the Circuit Resource Sharing Mode of Operation for Cross-Border Terrestrial Networks into the AP-IS Master Plan and Regional Cooperation Framework Document

Incorporate details of the circuit resource sharing mode of operation for cross-border terrestrial fibre-optic networks in the current AP-IS Master Plan and the Regional Cooperation Framework Document 2019-2022. In the next revision of the AP-IS Master Plan and Regional Cooperation Framework Document, provide details of the management and cooperation mechanism, and the method for the allocation of circuit capacity for financial settlement, and solicit comments from stakeholders.