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HARNESSING CROSS-SECTORAL INFRASTRUCTURE SYNERGIES

Executive Summary

This Staff working paper explores potential synergies in deploying fiber optic cables for data transmission and other infrastructures, chiefly transport and energy. It provides information on the cost of deploying fibre optics, exploring potential win-win strategies in the co-deployment and cohabitation of fibre and transport infrastructure and drawing lessons from good practices in the Asia-Pacific region and beyond. It contains a set of key policy measures to maximize win-win outcomes, which include synergies with the Asian Highway and Trans-Asian Railway. It also contains an examination of the potential of ICTs in making sustainable transport a transformative building block of sustainable development. Safer, more secure and efficient transport through the emergence of so-called intelligent transport systems is expected to play a key role in the evolution of sustainable development goals. The paper highlights major areas of work for policymakers measures on how to maximise these cross-sectoral synergies.

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Thinner than human hair and made of very pure glass, optical fibre strands are used to carry information via light signals that are modulated in wavelength and colour. Compared with traditional copper wires, the physical characteristics of optical fibre offer superior robustness, corrosion resistance, higher speeds of transmission and stronger isolation from external electrical interference. From the perspective of transmission, optical fibre also offers vastly superior bandwidth with far less loss over a longer distance.

The use of fibre optics was developed in the 1970s initially for telephone and television signal transmission. Fiber transmission technology gradually improved and by 1988, the first transatlantic fiber optic cable was deployed for telephone signal transmission. Improvements in the technology were rapid, and resulted in increases in transmission capacity of several orders of magnitude. In particular, the introduction of dense wavelengths digital multiplexing technology in the early 2000's multiplied by nearly a 100 times in a few months the transmission capacity of fibre optic. During the mid-1990s until the so-called dot-com crisis, many operators invested massively in optical fibre transmission networks in the United States of America and other developed countries. The emergence in these countries of meshed and dense fibre networks combined with market liberalization and regulatory reforms, resulted in lower prices for transmission capacity and facilitated further progress towards fixed-line broadband transmission, a process which continues to this day. Today, international internet backhaul is largely based on fiber, including in most developing countries. Fiber optic provides far more capacity than wireless or satellite, [1] even though these latter technologies can play a critical role in providing internet access where fiber cannot reach. Fiber can be used in the various segments of Internet traffic, starting from international backhaul (submarine cables or terrestrial connections across countries), to national backbones and access and local networks.

B. Fibre's role in next generation networks

The growing use of wireless technology for third generation (3G) and fourth generation (4G) mobile broadband and telephony is further increasing the demand for fibre. While this may appear contradictory, the situation arises from the need to better coordinate the activities of microwave-emitting antennas, as well as the need for higher traffic aggregation and backhaul.[2] It is also caused by the finite nature of the spectrum used for mobile communications. Furthermore, the growing ubiquity of data-intensive devices, such as tablets and so-called smartphones, greatly contributes to the increased demand for data transmission capacity and international transit, for example through increased demand for video streaming services. This situation is likely to increase the need for national and international fibre optic transmission capacity. Finally, it is sometimes argued that fibre is a "future-proof" transmission technology as innovations are usually associated with improvements in the transmission and routing equipment rather than in the fibre itself.

To reap full benefits from broadband, several countries in the region are implementing fibre deployment strategies, in particular fibre in local loops, or so-called FTTx strategies. [3] The configuration varies across and within countries in terms of distance between the fibre and the individual user. Local fiber networks can be described within the following major categories:

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[1] International cables, Gateways, Backhaul and International Exchange Points, OECD Digital Economy Papers, No. 232, OECD 2014.

[2] Organisation for Economic Co-operation and Development, "The development of fixed broadband networks", OECD Digital Economy Papers No. 239, (Paris, OECD Publishing, 2014). Available from dx.doi.org/10.1787/5jz2m5mlb1q2-en.

[3] "Fibre to the x", or FTTx, is a generic term for the "architecture" for any broadband network to furnish all or part of the local loop for "last-mile" telecommunications. For more information on these aspects, see www.thinkbroadband.com/guide/fibre-broadband.html.

- Fiber to the node (FTTN), where fiber ends at the backbone network and other technology ensure distribution over the access network, possibly for distances of several kilometres,

- Fiber to the cabinet (FTTC), where fiber reaches out deeper into the access network, into street cabinets, or poles located close to homes (typically within 300 meters). The end of the access network to users then uses high speed copper technology (such as DSL) or wireless technology (e.g. WIFI),

- Fiber to the home or fiber to the premises (FTTH/FTTP), where fiber reaches directly into individual homes or into buildings in businesses or multi-dwelling habitats.

C. Fibre network extensions in Asia and the Pacific

Fibre extension services are now common in Asia-Pacific countries, with Internet service providers often investing in last-mile connectivity.

China, in its recently launched broadband strategy, has also made as a key objective the connection of all new housing projects to fibre. Chinese operators will also make available FTTC (fibre to the cabinet) for at least 10 per cent of the population.[4]

Fibre optic transmission remains underdeveloped in many countries in the region. In fact, Asia and the Pacific is the region of the world with the largest gaps in terms of fixed broadband access and bandwidth per capita. However, there are clear opportunities in deploying fibre optic backbones alongside other major infrastructure. Unlike in developed nations, many developing Asia-Pacific countries did not experience the investment boom in fiber in the late 1990's which led to the increase in capacity and fall in transmission costs. According to the OECD fiber backhaul networks in many developing countries "(…) are not tightly integrated mesh networks, but rather more resemble river systems. At the coast, for example, an international submarine fibre lands and from here, the network spreads out throughout the country, gradually thinning out in capacity." As their fiber optic backbone and international backhaul systems are yet to be fully developed to cope with increased demand for data, ESCAP countries need to explore potential challenges and opportunities in facilitating their fiber network deployment, moreover, there are clear opportunities to be tapped in early deployment of this "future-proof" technology alongside other major infrastructure. Therefore there is a clear interest in documenting costs aspects of fiber deployment and potential synergies with other infrastructure sectors to bring down fibre deployment costs.

II. Elements of cost of fibre installation

Limitations in national backbones and access networks are among the obstacles to cheaper and higher-quality Internet access. Furthermore, as fibre will be increasingly important for the operations of future generations of mobile networks, the absence of an adequate fibre network could limit the extension of mobile broadband services. The cost of network deployment is therefore an important criterion influencing progress towards an inclusive information society. Elements of the costs connected with making available fibre networks are examined below.

A. Submarine fibre networks

At the international level, the costs for submarine cables are typically high but transmission capacity on these segments is huge and the data are transmitted over very long distances. Submarine cables typically connect a large number of countries across several continents, and their costs are in

[4] The Internet research firm Ovum has predicted that in 2015 China will have 76.5 million FTTx subscribers, more than half the global total.

the range of several hundreds of millions of dollars, which requires working through complex consortia for their financing.[5]

B. Terrestrial fibres

Whether they are used for international transit, intercity traffic or the local loop, terrestrial fibre optic cables are typically laid either in underground ducts (or conduits) or in the air, connected by pylons, such as those that transmit electricity. Fibre can also be deployed in ducts or in the air along other existing utility infrastructure, along city streets, highways, railways, pipelines, underground water or sewage conduits and even along canals.

Evaluating the cost of “rolling out” terrestrial fibre can be complex and location specific, but information is available, including from local loop extension projects. Such extensions are more often than not heavily focused on bringing fibre into urban areas, a process which tends to be expensive. Nevertheless, elements of costs for deploying fibre based on these strategies do help to shed some light on the potential cost of extending fibre backbones in developing countries in the Asia-Pacific region. As indicated in table 1, the evidence suggests that the greatest share of the cost of fibre deployment usually involves civil engineering work, including digging trenches, which typically accounts for up to 80 per cent of the total cost. This 80/20 per cent partitioning of costs applies in situations where new cables have to be deployed underground, involving trenching and laying of ducts. While these figures are available for developed countries where labour costs are higher, it is unlikely that the 80/20 ratio would differ significantly in developing countries. In fact, the World Bank assumes that this rule of thumb is relevant in the Middle East and the Northern Africa subregion.

Table 1 Share of civil engineering work in fibre deployment costs in selected countries/regions

Country/region	Approximate average share of civil engineering work in fibre deployment cost (percentage)	Source
France	Approximately 80	Government of France (www.ant.developpement-durable.gouv.fr/)
United Kingdom of Great Britain and Northern Ireland	Between 70 and 80	www.redburn.com www.beyondbroadband.coop www.cityfibre.com/
Republic of Korea	Between 80 and 90	KT Corporation
European Union	Approximately 80	FTTH Council of Europe
European Union	Approximately 80	European Commission, Analysys Mason Ltd.
Member countries of the Organisation for Economic Co-operation and Development (OECD) (2008)	Between 50 and 80	OECD

[5] See, for example, www.unescap.org/sites/default/files/Broadband%20Infrastructure%20in%20the%20ASEAN%20Region_0.pdf.

Middle East and Northern Africa	Approximately 80	World Bank

Source: ESCAP.

C. Aerial fibre networks and emerging burying techniques

Aerial placement of fibre optic cables is often a cheaper[6] but not always realistic option for backbone networks owing to such factors as climate, particularly in places exposed to intense snowfall and typhoons or cyclones. Maintenance may also require interacting with power lines, which can be dangerous and may require shutting off or redirecting the current, which may increase the cost to telecommunication operators. Despite these constraints, the lower costs of deployment and the possibilities for infrastructure cohabitation discussed below make aerial fibre deployment a proposition worth consideration by ESCAP members and associate members under certain conditions.[7]

The high share of the digging of trenches in the total cost of fibre installation has recently led to the emergence of alternative technologies for burying cables. These techniques typically involve specialized equipment to dig smaller trenches, or underground galleries and include micro-trenching, moleploughing, directional drilling and impact moling techniques.. Their benefits include lower costs, less disruption to road traffic and sometimes faster implementation.[8] The costs and benefits of these techniques could be worth exploring for ESCAP member States in the light of their national circumstances.

III. Building synergies through co-deployment

Given the significant share of civil engineering costs in total fibre deployment costs, there is an obvious incentive to look for opportunities to better utilize existing so-called dark fibre and conduits where they exist and for co-deployment where other infrastructure that uses fibre is being built or upgraded.

For various reasons, telecommunications operators and many utilities usually deploy excess fibre when building their networks. Such excess fibre remains unused and is called unlit or dark fibre. Likewise, telecom operators and utilities sometimes choose to lay out redundant ducts, which remain empty. This excess fibre or empty conduits can be sold or leased under indefeasible rights of use to carriers' telecom operators and become an important part in national backbones.

The benefits to be tapped may include shared investment costs and additional revenues for utilities and telecom incumbents that are earned by renting shared infrastructure. The reduction in the number of civil engineering works will also limit environmental degradation, as well as interference with road transport when ducts and cables are joined with major road works. Ultimately, however, co-deployment should drive down prices for telecommunication services that will result from improved access to fibre and increased competition.

A. Fibre along railways

Railways are typically heavy users of communication and sensor equipment, not least of all fibre optics, to address their traffic-monitoring, signalling and telecommunication needs. Railways

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6 By up to 90 per cent in France, if it is carried out on existing poles. See www.ant.developpement-durable.gouv.fr/le-point-sur-les-infrastructures-d-a17.html.

7 The first fibre backbone to be put into place in Timor-Leste was deployed in the air on its own networks of poles, by one of the three mobile telephone operators based in Timor-Leste.

8 "Installing fibre-optic cables underground", blog post by Neil Bradley in www.beyondbroadband.coop. Accessed 2 July 2014.

have therefore often deployed large-scale fibre optic networks along their existing rights of ways. The ESCAP region offers multiple instances of railways that have deployed extensive fibre optic networks for their operation and have leased out excess capacity to third parties.

China TieTong Telecommunication Corporation was founded in late 2000 to integrate and improve the telecommunication systems of Chinese railways. After carrying out much upgrading work on the network, China TieTong was transferred from the Ministry of Railways to the administration of the State-owned Assets Supervision and Administration Commission of the State Council in 2004, when it started offering a large variety of communications services to the public and the business sector, as well as to Chinese railway systems. Its fibre network, running along railway tracks, is more than 100,000 km long and extends over all the country's provinces, including most major cities.

TransTelekom is a subsidiary of Russian Railways, the national railway operator. It uses fibre deployed along Russian railways to provide a wide gamut of communication services, including retail and wholesale services. It reaches out deeply into the provincial market, with people living in settlements of fewer than 100,000 inhabitants, accounting of almost 40 per cent of all connections. In addition, the company also offers international transit services between Asia and Europe.[9]

RailTel Corporation of India constitutes yet another good example of how railway operators can commercially exploit fibre. By leasing its excess unused capacity on its fibre optic networks, RailTel has emerged as one of the largest telecom infrastructure providers in the country. In the process, RailTel has diversified its revenue incomes and achieved robust profit margins, part of which are being reinvested in infrastructure upgrades and maintenance. RailTel has attracted telecom providers, chiefly because this would enable them to avoid the major expenses inherent in civil works in remote locations. In addition, RailTel furnishes the telecom providers with its existing right of way that must be secured in order to access excavation sites and activate the optical fibre.

Finally, in Manila, the rights of way provided by the Manila Metro Rail Transit System and Manila Light Rail Transit System were utilized by the Integrated Government Project to lay out fibre. This project is aimed at interconnecting public offices with fibre in Manila, for information-sharing and the delivery of common applications among users.[10]

B. Fibre along roads and highways

Fibre optic systems can be used along roads and railways for traffic monitoring and management purposes. Deploying fibre along roads presents the considerable advantage of enabling easy access to the network for maintenance purposes. Furthermore, as is discussed below, fibre constitutes a key element of intelligent transport systems (ITS) that will form a key building block of the sustainable development goals of the development agenda beyond 2015. When laying fibre for ITS, road and transport authorities can ensure that they contribute to the national backbone extension if they also install additional fibre, or at least additional ducts that can be leased to lay out fibre subsequently.

C. Optical ground wire and aerial fibre networks

High-voltage electricity transmission systems also use fibre optics in optical ground wire (OPGW) on transmission lines for both grounding and communication purposes.[11] OPGW runs on the top of electricity transmission wires, on pylons, and their fibres are used by the electricity utility for communication purposes, to monitor the power transmission lines, and they can be leased or sold to

[9] For example, in 2007, it completed together with the Nippon Telegraph and Telephone Corporation of Japan an undersea fibre optic cable system linking the islands of Hokkaido (Japan) and Sakhalin (Russian Federation).

[10] Statement delivered by the representative of the Philippines during the Ministerial Round Table on Regional Connectivity for Shared Prosperity, which was held during the seventieth session of the Commission.

[11] An OPGW cable consists of a tubular structure containing one or several optical fibres surrounded by layers of steel and aluminum wire.

third parties for data transmission. The high-voltage lines below the fibre cables provide a degree of protection against vandalism, damage from rodents and other wildlife interference; however, unlike buried cable, they are not exposed to damage from excavation. For safety reasons, installation and maintenance can require shutting or diverting the transmission of high-voltage current to prevent accidents, and that process can be costly or impractical.

Examples of the use of OPGW for data transmission services abound in the ESCAP region, where power networks are gradually expanding along with economic growth. In India, POWERTEL has emerged as a major national carrier having one of the largest national terrestrial fibre backbones. The Power Grid Corporation of India (POWERGRID) is a State-owned electric utility company transmitting approximately 50 per cent of the total power generated in India. In 2001, it established POWERTEL as a telecom venture to operate its OPGW fibre network for wholesale data transmission capacity. POWERTEL's fibre network grew from 19,500 km to 25,000 km in 2012,[12] connecting more than 206 cities. Over the same period, POWERTEL's revenues tripled to about US$ 33.2 million. POWERTEL greatly benefits from the existing rights of way already established by POWERGRID. It also reaches out in less connected and remote areas of the country, hence potentially contributing to alleviating the urban/rural digital divide in India. POWERTEL plans to offer international connectivity services to Bangladesh, Bhutan, Nepal and Sri Lanka. It is planning to market the access to its 150,000 towers for telecom operators to mount transmission antennas, as well as extending its fiber network by another 33,000 km.

Although they do not share a common border, Bangladesh and Bhutan have recently renewed their discussions on trading electricity from Bhutan for bandwidth capacity from Bangladesh.[13] These South Asian countries would need to negotiate rights of way from India for the high-voltage electricity transmission lines and pylons. This would contribute to network redundancy in both countries, and the resulting increasingly meshed network would benefit all countries in the subregion, including India.

The deployment of new electricity transmission lines represents a clear opportunity to develop national backbones and access networks linking densely populated areas, using OPGW technology. Obvious synergies arise from established rights of ways, relatively low deployment costs and the creation of additional revenues for power companies. However, they need to be examined with caution in regions that are prone to frequent wind-borne disasters. For example, during Typhoon Haiyan in the Philippines in 2013, aerial electricity and telecom transmission systems were destroyed simultaneously in the worst affected areas, compounding logistical coordination in disaster responses and relief supplies.

Recent developments in electricity transmission technology, in particular high-voltage direct current transmission, have opened renewed prospects for the transmission of electricity over long distances. This could be of key importance in the ESCAP region, which includes countries with structural surpluses and deficits in terms of power generation. ESCAP member States have requested the secretariat to identify options on regional energy connectivity, such as an intergovernmental framework for developing an Asian energy highway, conceptualized as a regional integrated power grid.[14] For this initiative, it will be necessary to maximize the potential synergies in terms of cohabitation with fibre.

D. Optical fibre networks in other utilities

Fibre is becoming essential along pipelines, whether fibre is used to carry water, natural gas or other fossil fuels. Fibres are used by utilities for internal communication purposes, as well as to monitor these vital infrastructures against threats that include natural hazards and human intrusion.

[12] See www.tele.net.in/company-stories/item/10955-powertel-riding-on-the-demand-for-high-bandwidth-services. Accessed 11 July 2014.

[13] See lirneasia.net/2014/05/power-grid-to-energize-bangladesh-and-digitize-bhutan-india/.

[14] See www.unescap.org/events/expert-group-meeting-asia-pacific-energy-highway.

Fibre optic distributed sensing technology can be used to help keep track of changing pressures, temperatures and ground movements, among other such uses which help in detecting and pinpointing the occurrence of events on pipeline networks before they develop into an actual threat. For example, this approach is critical in identifying leakage. The fibre helps identify the precise location of such an incident in real time, which facilitates tailoring the response to threats.[15] In the light of this, many pipeline owners and operators are deploying distributed fibre sensing technology on their infrastructure, both above and below ground. Supplementary fibre capacity could be leased or sold for commercial telecommunications purposes.

GAIL (India) is the country's largest natural gas processing and distributing State-owned company. It set up GAILTEL in 2001 as an affiliate to market communication services using the firm's redundant fibre capacity. GAILTEL has deployed approximately 10,000 km of fibre along its pipelines and the country's road network. GAILTEL leases dark fibre and duct space in indefeasible rights of use agreements. It also offers colocation facilities, for an annual revenue of approximately US$ 4 million.[16] Fibre has also been laid over pipelines; fibre is being used successfully for data transmission in other regions, for example in Africa along the Chad-Cameroon pipeline.[17]

E. Additional synergies applicable to fibre networks

Fibre optic capacity for sensing and detecting changes in the surrounding environment opens interesting potentials in terms of large-scale environmental monitoring. This can be applied in disaster warning systems, as submarine cables can detect and report sudden tectonic activity or abrupt water movement preceding a tsunami. In cases when a threat is detected, the early warning can enable the adoption of protection measures on the coasts or other exposed areas and such measures can greatly mitigate the impact of a disaster. Submarine cables equipped with sensors could also comprise great tools for tracking water temperatures and thereby help to monitor global climate change.

The International Telecommunication Union (ITU) together with the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization have launched an initiative to promote the use of submarine fibre optic cables laid out by telecom operators and carriers to develop a network of sensors and detectors at the bottom of the sea. Under the initiative known as Submarine Cables for Ocean/Climate Monitoring and Disaster Warning, a strategy and road map have been launched to equip submarine cable repeaters with scientific sensors for climate monitoring and disaster risk reduction.[18] This initiative offers interesting perspectives for monitoring over the long term climatic evolutions, as well as seismic activities.

IV. Policy measures to maximize the synergies across infrastructure sectors

Increasingly, countries are taking measures to tap these important potential synergies to stimulate co-deployment and cohabitation. At this stage, such efforts are still being spearheaded by developed countries, but they often constitute valuable examples which could be tailored to the situations of ESCAP developing countries. Potential also emerges in using the possibilities offered under regional cooperation intergovernmental agreements, such as the Asian Highway and Trans-Asian Railway network agreements, to boost the development of fibre transmission networks at the regional level. Measures to boost co-deployment and other synergies are detailed below.

[15] See www.princeton.edu/~bglisic/Glisic_Pipeline.pdf.

[16] See www.slideshare.net/jinvaibhav1/gailtel.

[17] See www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR08/PDF/Cameroon_E.pdf.

[18] ITU, WMO and IOC, *Using Submarine Cables for Climate Monitoring and Disaster Warning: Opportunities and Legal Challenges* (ITU, 2012). Available from www.itu.int/dms_pub/itu-t/oth/4B/04/T4B040000160001PDFE.pdf.

A. Advocacy and transparency

Except for the railway organizations mentioned above which lease their fibre networks on commercial terms, traditional utilities (roads, electricity, water networks and pipeline operators) are not always aware of the potential benefits of co-deployment in terms of reduced investment costs or the potential revenues that could be gained from leasing duct space and capacity on fibre. Such commercial advantages are perhaps least obvious to traditional utilities that are State-owned or that retain a strong public sector culture. Hence, one of the short-term priorities in developing countries in the Asia-Pacific region should be to raise their awareness as to the potential commercial benefits of co-deployment and passive infrastructure rental. As discussed in the previous section, there are a number of good practices in the region that can be used as reference guides for the way forward.

Increased knowledge of the benefits of infrastructure-sharing is not sufficient however. For the synergies to materialize, another condition is access to reliable information on both existing infrastructure and planned civil engineering works. Such information can be made public in various forms. The European Commission, for example, has issued a proposal for a European Union initiative[19] to reduce the cost of high-speed broadband infrastructure deployment, which includes a series of measure that would facilitate cross-infrastructure synergies in deployment. The first one of these measures is a call to establish national atlases of all available passive infrastructures (ducts, dark fibre, poles and other transmission lines) that could be used by telecom operators. Another approach could consist of mapping all civil engineering work with potential passive infrastructure supply, as such work is performed. Transparency can also be improved through the development of a database, or single information point, to include all planned civil works of potential interest to deploy fibre. In France, for example, civil engineering works above a pre-defined threshold [20] need to be reported to telecom operators and local authorities through a specialized entity. Interested parties then have a six-week window to express their interest in joining the works, which the utility commissioning the work is mandated to accept. The telecom operator (or local authority) wishing to lay the ducts is required to compensate the utility for the additional expenses incurred. The compensation is established against a set of pre-defined criteria and depends on the diameter of the ducts or the weight of the cables if they are to be deployed on electricity poles.

While the provision of this information is important at the national level to foster co-deployment, the adoption of such transparency measures may be even more important at the regional level when cross-country infrastructure projects are envisaged. A regional or subregional database of planned infrastructure projects with co-deployment potential could be created at the regional level, possibly managed by the ESCAP secretariat, which already has experience in collecting network information in the transport, energy and ICT sectors. This would include all major cross-border road, railway, electric transmission and pipeline projects. Maps [21] of the Asia-Pacific information superhighway already constitute a first repository of information on existing fibre networks, and they include information on ESCAP transport networks (the Asian Highway and Trans-Asian Railway). These maps could be further enriched by including additional information on other cross-country infrastructure projects with co-deployment potential.

B. Regulatory and institutional aspects in ensuring rights of way and open access

Regulatory frameworks also need to be adjusted to ensure that the synergies materialize. This can take many forms and each ESCAP member State will need to reflect what adjustments need to be made to its own specific regulation system. Reviews of the regulatory framework should be aimed at

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[19] The proposal by the European Commission was issued as a directive and was endorsed by the Council of the European Union and the European Parliament in early 2014. European Union member States will need to implement it by July 2016. See www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/trans/141234.pdf.

[20] The minimum threshold for reporting civil engineering works is a length of at least 150 metres in urban areas or 1 km in rural areas. See www.ant.developpement-durable.gouv.fr/le-point-sur-l-article-l49-du-cpce-a509.html.

[21] See www.unescap.org/idd/maps/asia-pacific-superhighway/.

achieving a double objective: on one hand, they should generally promote the usage of the utilities' existing rights of way by actors deploying the fibre; on the other, they should also promote open access to the fibre operators, that is, non-discriminatory access to cohabiting infrastructure at a reasonable cost.

Current jurisdictions sometimes are limited to one clearly stated objective concerning the rights of way that are granted to utilities to deploy their networks through public land or private property. This single purpose right of way is often related to the provision of one unique type of public service (electricity or water, for example). The legislation of ESCAP members and associate members should ensure that every time a right of way has been granted to a utility to deploy its network, it is automatically extended to fibre deployment, either simultaneously or subsequently. In order to further facilitate rights of way, one recommendation of interest is the creation of a one-stop shop on rights of way and administrative procedures.[22] Obtaining all the necessary information from a centralized institution can help operators save time and money.

While reviewing good practices in the European Union, researchers reported [23] that mandated access to passive infrastructure was an important measure to decrease the cost of network deployment. Providing mandatory access also applies to telecom operators themselves, in particular the historical incumbent, in addition to other utilities. The authors noted that, while in the short term, synergies seem to happen mostly between telecom operators sharing their ducts, in the longer term, electricity utilities could be increasingly interested in sharing their infrastructures with telecom operators as they could in return obtain the Internet backhaul necessary for implementation of so-called smart grids. Likewise, for transport infrastructures it is increasingly likely that advantages will be perceived regarding laying out fibre to enable intelligent transport systems. The "dig once" sets of policies of the United States of America require that individual states in that country install broadband conduits during the construction of federally funded highway projects. Access to such conduits should be available for a cost-based charge.[24]

Ensuring open-access to fibre or ducts in other infrastructure is one of the ways to increase competition and bring down ICT prices. The case for open access is further strengthened when public funding is provided to deploy infrastructure. Open access requires that all operators are afforded market entry to the infrastructure on similar conditions. It typically requires establishing clear guidelines of non-discrimination between telecom operators and access to the utility infrastructure at fair prices, which include the recovery of costs in addition to a small profit margin. Rental and maintenance charges of passive infrastructure may need to be regulated to ensure that the physical infrastructure owner receives adequate incentives to continue building and maintaining it.

C. Addressing the regional dimension in cross infrastructure synergies

Ensuring a seamless terrestrial connectivity is particularly important in ESCAP, whose membership counts several landlocked developing countries that are typically facing very high prices for Internet transit. In the ESCAP region, therefore, the regional dimension of infrastructure synergies across countries is of particular importance. ESCAP countries should seek to tap on the numerous cross-country or pan-regional infrastructure deployment projects that are facilitated by the current high economic growth in the areas of transport, energy, water, etc. ESCAP member States could decide to systematically co-deploy fiber along regional infrastructures, on an open-access basis. Given the increasing visibility of this issue, it should not be too difficult to convince International Financial Institutions and other international donors to endorse the principles of mandated co-

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[22] Matt Yardley, Rod Parker and Mike Vroobel, "Support for the preparation of an impact assessment to accompany an EU initiative on reducing the costs of high-speed broadband infrastructure deployment", a study prepared for the European Commission, DG Communications Networks, Content and Technology, by Analysys Mason Limited, 2012. Available from ec.europa.eu/digital-agenda/en/news/support-preparation-impact-assessment-accompany-eu-initiative-reducing-costs-high-speed

[23] Ibid.

[24] United States Government Accountability Office, "Planning and flexibility are key to effectively deploying broadband conduit through Federal highway projects", Washington, D.C., 2012. Accessible from www.gao.gov/assets/600/591928.pdf.

deployment on an open access basis, especially since this is bound to lead to substantial savings and revenue generation sources. In addition, when deploying cross-regional infrastructures, ESCAP countries should systematically consider deploying additional fiber or ducts. When relevant, universal access funds financial resources may be considered to cover for the projects additional expenses.

The ESCAP secretariat has proposed to systematize co-deployment of fibre optic cable along the Asian Highway and Trans-Asian Railway, two transport international agreements for which it acts as secretariat. The Asian Highway and Trans-Asian Railway play a catalytic role in the coordinated planning and construction of international roads and railway lines in Asia and help countries optimize the use of their infrastructure by creating intermodal transport opportunities. This proposal by the ESCAP secretariat was discussed during the 4th session of the ESCAP ICT Committee in Bangkok, in October 2014.[25] The proposal will be examined by the respective organs in charge of the two Agreements under the ESCAP aegis. Concretely, this could entail systematically deploying additional ducts and/or fiber when building the infrastructure that constitutes these two networks. In the case of the Trans-Asian Railway, spare fiber could be deployed in addition to that installed for the use by the railway itself. In both cases, the additional ducts and fiber could be rented to telecom operators or other data carriers, in order to provide an additional source of income for the roads and railways entities. It is important that in either case, access be made open to all potential operators, on a non-discriminatory basis and at reasonable cost.

High-voltage transmission lines are being utilized at the regional level to build cross-country meshed fiber optic cables backbones. A good example is the SIEPAC system in Central America that connects the national high voltage transmission grids of 6 Central American Nations.[26] The 1793 kilometers long network of transmission lines includes an OPGW cable of 36 fibers.[27] In order to exploit the fiber, and proceed with the required complementary investments to finalize the backbone, the regional entity owing the network created a network operator: REDCA,[28] which acts as regional carrier in connecting national backbones. The REDCA network also connects the Mexican terrestrial backbone and is building an extension to connect to the Colombian network.[29] It is expected to bring much needed redundancy to the national backbone of the Central American nations, which are currently heavily dependent on submarine cable access. This example of co-deployment at the regional level between developing countries bears some relevance for ESCAP countries that plan to interconnect their national electricity grids at the subregional level.

Recent developments in electricity transmission technology, in particular high-voltage direct current transmission, have opened renewed prospects for the transport of electricity over long distances. This could be of key importance in ESCAP which includes both countries with structural surpluses and deficits in terms of power generation. ESCAP member States have asked the secretariat to lead a regional reflection on a potential Asian Energy Highway.[30] This initiative will need to maximize the potential synergies in terms of co-habitation with fiber. This would not only reinforce access to fiber and IP transit in ESCAP landlocked countries, but also generate additional sources of income for the national electricity grids. The ESCAP secretariat will keep reviewing and advocating for the case for co-deployment of fiber on regional energy infrastructure. Through its multi-sector expertise ESCAP is well placed to facilitate such cross-sectoral interventions.

25 See www.unescap.org/resources/draft-report-committee-information-and-communications-technology-fourth-session

26 SIEPAC (Sistema de Interconexión Eléctrica de los Países de América Central) connects 37 million consumers in Panama, Costa Rica, Honduras, Nicaragua, El Salvador, and Guatemala. See en.wikipedia.org/wiki/SIEPAC.

27 See www.ceaconline.org/documentos/Desarrollo_del_Proyecto_SIEPAC.pdf.

28 See www.redcasiepac.com/index.php/es/

29 See www.proyectomesoamerica.org/joomla/index.php?option=com_content&view=article&id=175&Itemid=104

30 See www.unescap.org/events/expert-group-meeting-asia-pacific-energy-highway

V. Information and communications technology and transport convergence towards intelligent transport systems

In addition to offering prospects of mutual synergies in its deployment and cohabitation with other infrastructure, ICT as a meta-infrastructure can play a transformative role when incorporated into these other infrastructures. Rapid progress in information processing and transmission capacity have enabled the emergence of the "Internet of Things" and so-called smart infrastructures.[31] In the area of transport, such progress has permitted the gradual emergence of the previously mentioned intelligent transport systems. This section provides a brief presentation of such systems, their development benefits and a few policy recommendations to facilitate their emergence at the regional level in Asia and the Pacific.[32]

A. Definition of intelligent transport systems and development benefits

While there is currently no single internationally agreed definition for intelligent transport systems, ITS is generally understood to be the combination of technologies, most of which involve ICT as a platform, that are embedded within conventional transportation infrastructure for which increased traffic efficiency, safety and security are sought. They include telematics and all types of communications in vehicles, between vehicles and between vehicles and infrastructure. Concretely ITS may make use for transport of technologies such as:

- telecommunication networks (fixed and mobile)
- automatic identification systems
- systems for automatically locating vehicles
- protocols for the electronic exchange of data
- GIS systems
- systems for the collection and classification of traffic data
- Systems to count the number of users in public transport systems .

Typically, ITS can address traffic congestion, reduce traffic accidents, mitigate environmental externalities generated by road transport and more generally improve efficiencies along geographically dispersed supply chains by improving logistics and facilitating multimodal transport, including public transport. ITS can therefore greatly contribute to the three pillars of sustainable development by reducing travel times, saving fuel and reducing carbon dioxide and pollutant emissions, and improving transport safety and security, as well as increasing the comfort of users and creating new lines of economic activity.[33]

B. Applications of intelligent transport systems

Central to ITS is the collection, analysis and distribution of traffic information using sensors, transmitters and broadcasting. This approach provides drivers with spatially and temporally accurate information on traffic. Traffic management systems can then utilize the traffic information to modify traffic flows using signal control systems, with a view to smoothen the traffic by slowing it or reducing the inflows of vehicles. Electronic toll collection and electronic road pricing systems can further contribute to traffic management systems.

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31 See E/ESCAP/CICT(3)/2.

32 This section is drawn largely from a forthcoming ESCAP paper on ITS for development in Asia and the Pacific.

33 ITS Asia-Pacific Secretariat, "ITS guideline for sustainable transport in Asia-Pacific", 6 December 2013. Available from www.its-jp.org/english/its_asia/1153/.

Information systems can also improve the provision of public transport services in several ways, for example by helping to identify demand for new routes, by automating payment systems or by using traffic signal control to prioritize public transport.

ITS improves transport fleet management, security of transport process, customs control of cross-border and transit traffic and formalities at border crossings, which can significantly increase efficiencies, reduce costs and lessen adverse environmental impacts. As part of its efforts to promote efficient cross-border transport, the ESCAP secretariat has developed several models showing how ICT applications can be adapted and applied to cross-border and transit transport.

C. Promoting intelligent transport systems at the regional level: Areas for action

Intelligent transport systems rely extensively on high-speed and high-capacity communication facilities. It is important therefore to continue deploying communication infrastructure, in particular along, or in close proximity to, major roads where such systems are envisaged. ITS require both fibre and wireless communications, with fibre facilitating real-time communications between a wide variety of field devices and traffic control centres.[34] Fibre for ITS will need to be more systematically deployed along major roads, which could provide opportunities for co-deployment as discussed above. Wireless systems are also extensively utilised in ITS, but they can be jeopardized by interferences and crossings in transmission frequencies. This issue will require improving the allocation of ITS frequency bandwidth at the national level. Regional cooperation is doing this is essential to ensure compatibility across the national systems.

Developing countries usually utilize international standards to organize and articulate ITS modules. These standards and international models are developed under the aegis of the International Organization for Standardization. The active participation of ESCAP developing countries is important to ensure that standards evolve with relevance to various developmental exigencies.

ITS will increasingly rely on open data and so-called big data systems. Advanced Asia-Pacific countries, such as the Republic of Korea, are already making use of open and big data to improve their transport systems, for example by developing applications to assess the demand for public transport routes. A close corollary to this trend is the need to ensure personal data security and privacy, which require strong authentication and authorization procedures. ESCAP countries will therefore need to ensure that their statistical systems and regulatory frameworks foster the usage of big data and open data systems, while ensuring data privacy and security.

As an agency with expertise in both transport and ICT policies and an increasing cross-sectoral approach, ESCAP is well placed to facilitate policy dialogue and regional cooperation in developing Intelligent Transport Systems that are supportive of sustainable development objectives. The secretariat could act with regional experts and stakeholders to track good practices and promote a regional knowledge base in ITS.

VI. Conclusions and policy recommendations

In building a terrestrial meshed network of fibre, there is a strong incentive to leverage synergies across infrastructure sectors, notably with transport. A number of good practices exist in the ESCAP region and beyond. They typically result in win-win outcomes, including additional revenues for hosting utilities, and cheaper and more extensive fibre deployment which should ultimately contribute to improved access to ICT at the national and regional levels.

In light of the above, major policy options for ESCAP countries are presented below. They were discussed at the joint session of the ICT and Transport Committees, held in Bangkok on 15 October 2014.

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[34] www.fiber-optics.info/articles/fiber_optic_intelligent_traffic_systems.

(a) Legislation at the national level to encourage open access to passive communication infrastructure would ultimately contribute to cheaper broadband access.

(b) Raising awareness, transparency and eventually systematically opening new civil engineering works to co-investment and co-deployment opportunities would also contribute to cheaper access to fibre This could include establishing atlases of existing passive infrastructures and databases of planned civil engineering works that could offer co-deployment opportunities.

(c) Existing rights of way of traditional utilities could be automatically made available for fibre deployment, and a one-stop centralized system to acquire rights of way could be created to facilitate the process. International financing institutions and donors could introduce co-deployment of infrastructure on an open-access basis as a systematic requirement for cross-country infrastructure projects.

(d) ESCAP countries should consider amending the Intergovernmental Agreement on the Trans-Asian Railway Network and the Intergovernmental Agreement on the Asian Highway Network to include recommendations that encourage systematic fibre co-deployment. This recommendation will now be discussed under the respective mechanisms in charge of regularly reviewing the implementation of the Asian Highway and Trans-Asian Railway Agreements. ;

(e) To reap the potential sustainable development benefits of intelligent transport systems, ESCAP countries could accelerate the deployment of transmission capacity along the region's main roads and improve wireless frequency allocation;

(f) ESCAP countries should also ensure that their regulatory frameworks are conducive to the use of big data and open data, including in the transport sector which will increasingly be a central component of intelligent transport systems.

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