Digital Connectivity Webinar Series

European Commission's Directorate-General for International Partnership (DG INTPA) Unit F5

22, 25, 26, and 27 April 2022

Webinar 2: Implementation of Digital Connectivity

Webinar 2: Implementation of Digital Connectivity

Part 1: Foundations of Digital Connectivity: technologies and trends

- Fundamentals of the digital network architecture and ecosystem: network elements and trends on digital technology development
  - Concepts and importance of data transmission, performance, and the technologies to carry data flows
  - Most used telecommunication mediums (fibre cables, submarine, satellite, microwave, copper) and differences between them (latency and bandwidth)
  - Basics on installation and design of backbone, back-up route, trenching, branching unit, landing station, antennas, etc
  - Operation and maintenance of data transmission infrastructures to guarantee quality of service
  - Concepts and roles of Internet exchange points (IXPs) and data storage solutions (data centres), and how to protect data transmission links (cybersecurity)
- Quiz: Are fixed and mobile broadband services complements or substitutes?

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Webinar 2: Implementation of Digital Connectivity

Part 2: Foundations of Digital Connectivity: financial aspects of digital infrastructure development

- Financing the digital connectivity: public budget shortage, the universalization strategies, and the social relevant appeal projects
  - Doing Business in developing countries: opportunities and threats
  - Exploring the architecture of cost of capital in developing nations (opportunity cost of financing digital infrastructure, and basics on WACC calculation)
- Fundamentals of the financial aspects of digital infrastructure development
  - Overview on the costs of telecommunication infrastructures
  - Business models for retail and wholesale digital connectivity services
  - Case study: Ella link and how it works to finance and develop a submarine cable
  - Financial tools (grants, guarantees, digital bonds, the role of development banks, etc
  - Different actors involved and the private sector role: telecom operators, promoters, suppliers, etc
- Quiz: What are the main challenges and alternatives to attract private investment to bridge digital connectivity gaps in developing countries?

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Learning outcomes:

- learn the foundations of the digital network architecture and ecosystem
- get knowledge about main concepts and importance of data transmission, performance, and the technologies to carry data flows, the most used telecommunication and differences between them, basics on installation and design of network connectivity infrastructure, its operation and maintenance to guarantee quality of service
- Understand the main concepts and roles of Internet exchange points (IXPs) and data storage solutions (data centres), and how to protect data transmission links (cybersecurity)
- understand the financial aspects of digital infrastructure development, like the costs of telecommunication infrastructures, the common business models for retail and wholesale digital connectivity services, financial tools available to enable investment, and the different actors involved in the development of digital ecosystem (telecom operators, promoters, suppliers, etc.).

Part 1- Implementation of Digital Connectivity

Fundamentals of the digital network architecture and ecosystem£


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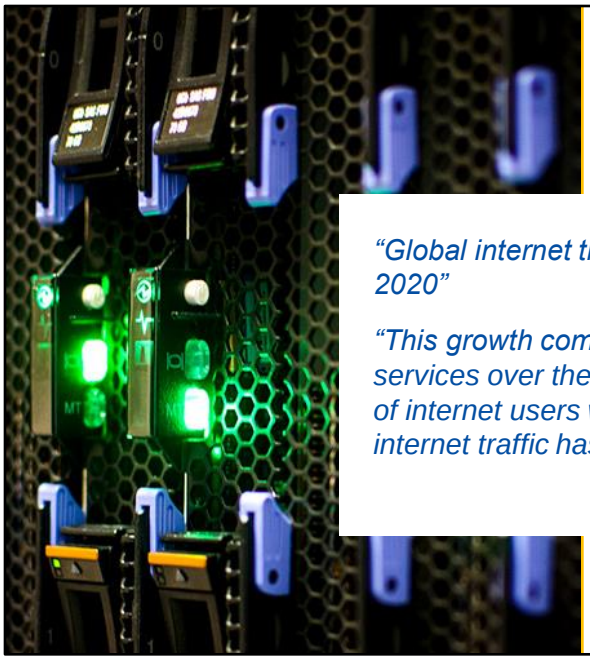
I. Concepts and importance of data transmission, performance, and the technologies to carry data flows



"Global internet traffic surged by more than 40% in 2020"

"This growth comes on top of rising demand for digital services over the past decade: since 2010, the number of internet users worldwide has doubled, while global internet traffic has expanded 15-fold."

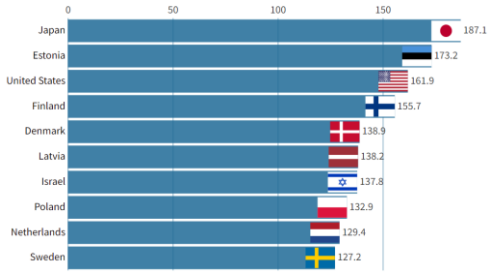
IEA, 2021

European Commission

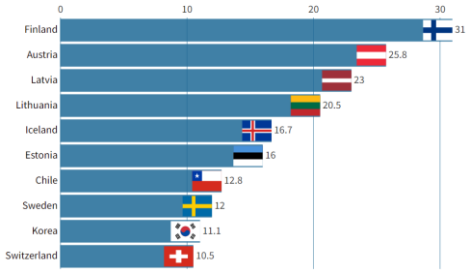
https://www.iea.org/reports/data-centres-and-data-transmission-networks

Drivers of data transmission flow trend

Mobile broadband subscriptions per 100 inhabitants, June 2021



Monthly mobile data usage per mobile broadband subscription, 2020 (GB/month)



- Data transmission rate is among the most dynamic characteristics of broadband services.
- key factor for service usability and customer experience, as well as expanding the possibility of application use.

Source: OCDE, 2021

Notes: Top 10 OECD countries

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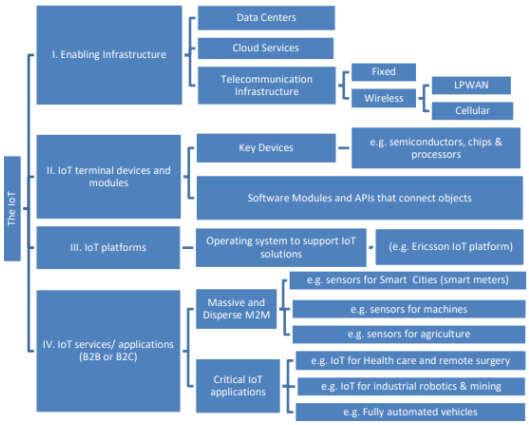
https://group.ntt/en/newsrelease/2019/03/07/190307a.html?_gl=1*124zwqc*_ga*MTg3NDA4MTQ3My4xNjQ4NzcxMDM1*_ga_5CBG7Y69V5*MTY0ODc3MTAzMy4xLjAuMTY0ODc3MTAzMy4w&_ga=2.131965519.1984268397.1648771035-1874081473.1648771035

https://www.oecd.org/digital/broadband/broadband-statistics/

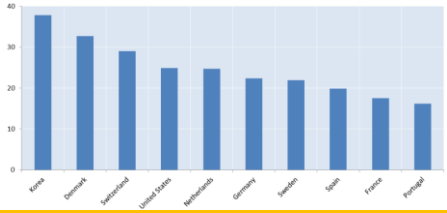
The role of new technologies: from connecting people to connecting things

IoT enabling environment



Source: OCDE, 2018

Devices online per 100 inhabitants, top OECD countries



IoT: Concept

"The Internet of Things includes all devices and objects whose state can be altered via the Internet, with or without the active involvement of individuals"

Source: OCDE, 2018

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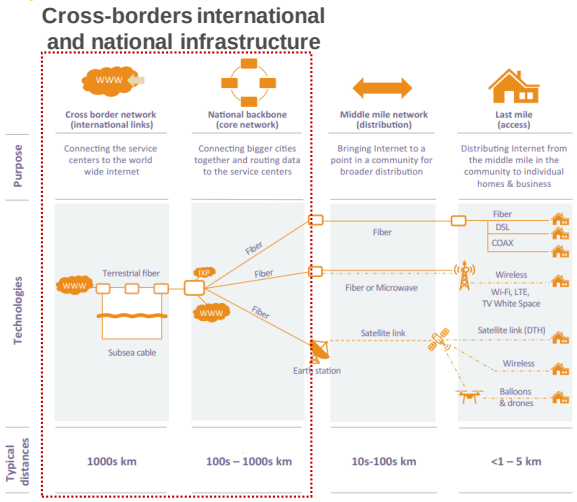
https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/CDEP/CISP/MADE(2017)1/FINAL&docLanguage=En

Technologies to carry data flows



Source: WB, 2018

Highlights

- Enable local networks to connect to the wider Internet.
- Assure access to regional and international high-speed networks.
- Fibre networks form the basis of backhaul networks, with some niche applications for microwave and satellite.
  - A fibre pair can carry as much traffic as all geosynchronous satellites combined together.
- In most OECD countries backhaul networks have become interconnected meshes crossing borders and complimented by multiple Internet Exchange Points
- (IXPs) and direct interconnections between networks. This allows traffic to be rerouted when necessary and provides competition and alternative paths.

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https://www.oecd-ilibrary.org/docserver/5jz8m9jf3wkl-en.pdf?expires=1649772685&id=id&accname=guest&checksum=739CF34E004F90579964D1F0F5FA8282

https://openknowledge.worldbank.org/bitstream/handle/10986/31072/132845-7-12-2018-17-20-11-InnovativeBusinessModels.pdf

Submarine fiber networks: facts

- The first intercontinental submarine fibre was the trans-Atlantic TAT-8 cable installed in 1988
  - It could carry 591.2 Mbit/s
- Investment in submarine fibre has averaged from USD 1 billion to USD 2 billion per year
- Modern Submarine Fibres´ capacities of 80 channels of 40 Gbit each for 3.2 Terabit per fibre pair
  - can be upgraded to 100 Gbit/s* channels, 500 Gbit/s super-channels and optical component.
  - manufacturers expect 1 Tbit/s channels to be available by 2020, allowing a single fibre pair to carry up to 100 Terabit/s

* For reference, a 100 GB 4K movie can be download in 8 seconds with a 100 Gbps speed.

- Preferred technology for carrying data over large distances in and between countries separated generally by oceans or large expanses of water
- Less prone to failure than over-land cables
- Capable of carrying enormous amounts of data
  - A single intercontinental submarine fibre can potentially carry more data, with less delay than could be achieved by combining all the world's active geostationary communications satellites together

Source: OECD, 2014

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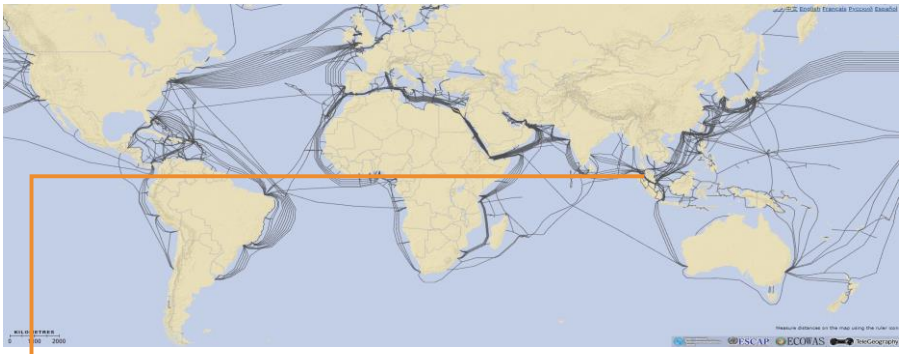
https://www.oecd-ilibrary.org/docserver/5jz8m9jf3wkl-en.pdf?expires=1648671665&id=id&accname=guest&checksum=45370960105696738D6F0F4B7D13C82E

The economic impact of subsea cables



Example: The Direct and Indirect Economic Impact of Subsea Cables on Indonesia

Indicator	Time period	Outcome
Economic growth	2012—2017	5.4% increase in gross domestic product (GDP) per capita
Employment	2012—2017	5.5% increase in service-sector employment over 6 years
Long-term economic growth	1997—2017	0.41% increase in GDP per capita for every 10% increase in international bandwidth consumption per user

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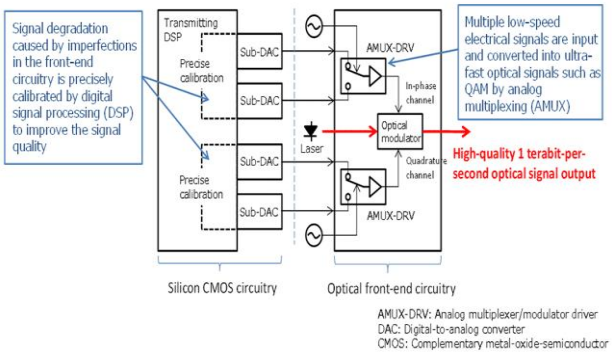
Source: RTI, 2020

https://www.rti.org/publication/economic-impacts-submarine-fiber-optic-cables-and-broadband-connectivity-indonesia/fulltext.pdf

Technology frontier: Optical Fibre



NTT New technology

- Multiplex function: the required bandwidth of electrical signals between the two circuit blocks reduced by half compared with conventional equipment
- Calibration technology: allowed generating high-quality optical signals with large numbers of modulation levels and multiplexed signals

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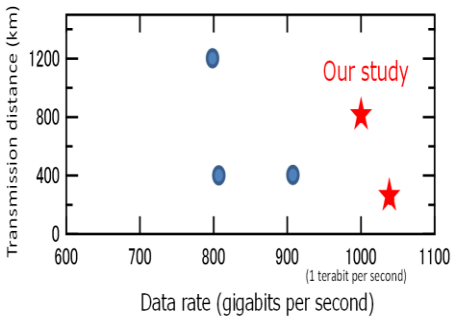
https://group.ntt/en/newsrelease/2019/03/07/190307a.html?_gl=1*124zwqc*_ga*MTg3NDA4MTQ3My4xNjQ4NzcxMDM1*_ga_5CBG7Y69V5*MTY0ODc3MTAzMy4xLjAuMTY0ODc3MTAzMy4w&_ga=2.131965519.1984268397.1648771035-1874081473.1648771035

Technology frontier: Optical Fibre



Source: NTT, 2020

NTT New technology

- Success in long-distance transmission of ultra-high capacity 1 terabit/second optical signal
- Expected to provide large-capacity network communications for IoT and 5G services
- World's longest transmission in commercial environments: 1,122 km

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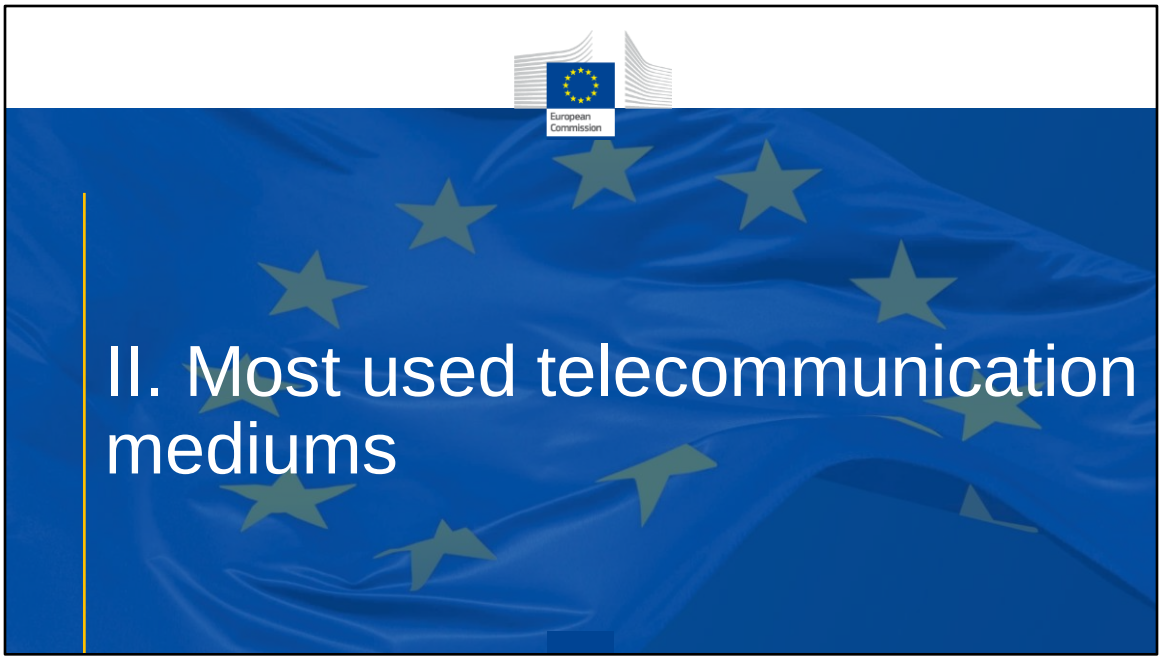
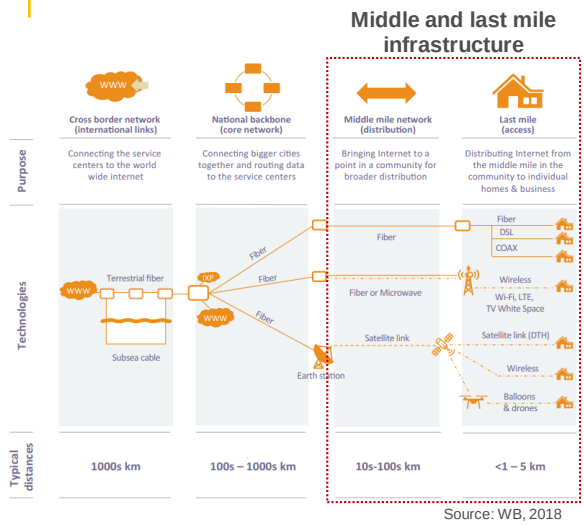
https://group.ntt/en/newsrelease/2019/03/07/190307a.html?_gl=1*124zwqc*_ga*MTg3NDA4MTQ3My4xNjQ4NzcxMDM1*_ga_5CBG7Y69V5*MTY0ODc3MTAzMy4xLjAuMTY0ODc3MTAzMy4w&_ga=2.131965519.1984268397.1648771035-1874081473.1648771035



II. Most used telecommunication mediums

Most used telecommunication mediums



Source: WB, 2018

Services features defines preferencial Middle and last mile infrastructure

- **Mobility:** communicate anytime, anywhere, with anyone
- **Latency:** synonym for delay (low latency leads to improved usability and better user experience)
- **Bandwidth:** volume of information that can be sent over a connection in a measured amount of time (Mbps)

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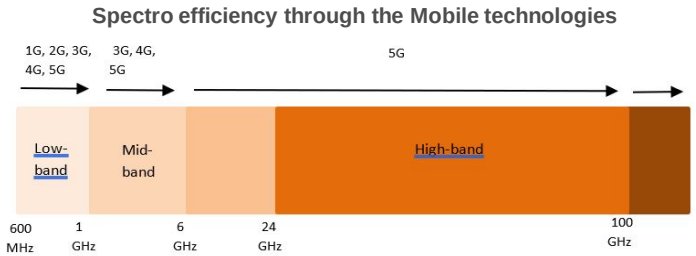
https://openknowledge.worldbank.org/bitstream/handle/10986/31072/132845-7-12-2018-17-20-11-InnovativeBusinessModels.pdf

Technology answer to demand: network coverage between 3G, 4G, 5G



- 4G is more spectrally efficient than 3G, just as 5G is more spectrally efficient than 4G
- Every leap in network performance or capability is called a new generation
- Average download speeds:
  - 3G: 7.4Mbps
  - 4G: 36.4Mbps
  - 5G: 100Mbps-200Mbps

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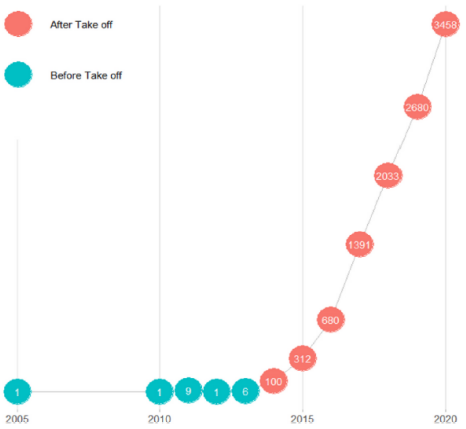
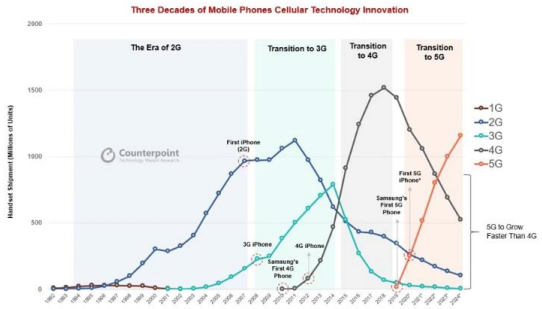
https://justaskthales.com/en/reader-response-whats-the-difference-in-network-coverage-between-3g-4g-5g/#:~:text=4G%20is%20more%20spectrally%20efficient,lot%20of%20hype%20around%205G.

Waves of technology development: the 5G

Scientific publications on 5G (2005–2020)



Source: Mendonça et al., 2022



The beginning of 6G

Year	Articles	Countries
2015	1	China (1)
2016	4	UK (2); France (2); Germany (2); Spain (2); Saudi Arabia (1); Malaysia (1); Poland (1); Sweden (1); Denmark (1); Greece (1); Italy (1)
2017	7	China (4); US (1); Turkey (1); Malasia (1); UK (1); Pakistan (1); Saudi Arabia (1); Spain (1)
2018	14	China (6); UK (4); South Korea (2); Pakistan (2); Canada (1); Greece (1); Japan (1); Serbia (1); Russia (1); India (1)
2019	39	China (22); UK (7); US (6); Canada (4); South Korea (3); India (3); Australia (2); France (2); Finland (2); Singapore (1); Japan (1); Iran (1); Qatar (1); Iraq (1); Pakistan (1); Luxembourg (1); Spain (1); Sweden (1); Ireland (1); Brazil (1); Russia (1); Serbia (1); Ukraine (1)
2020	121	China (50); US (30); UK (14); Japan (10); Finland (9); India (8); Canada (8); Saudi Arabia (6); South Korea (6); Italy (6); Turkey (6); Spain (5); Australia (5); France (5); Germany (5); Malasya (3); Greece (3); Portugal (2); Poland (2); Denmark (2); Brazil (2); Singapore (2); Sweden (2); Egypt (1); Colombia (1); Czech Republic (1); Israel (1); Sri Lanka (1); Belgium (1); United Arab Emirates (1); Cyprus (1); Netherlands (1); Ukraine (1); Slovakia (1); Chile (1); Austria (1); Russia (1); Bangladesh (1); Pakistan (1); Croatia (1)

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https://www.sciencedirect.com/science/article/abs/pii/S0308596122000301

Quality of Service (QoS): another driver of enhanced transmission flow capacity

QoS technical and non-technical point of view, and customer satisfaction

Source: ITU-T Supplement 9 to Rec. Series E.800 (12/2013)

Customer Satisfaction?

- Dependent on customer expectations and on technical and non-technichal aspects of the service provision
- QoS depends on end-to-end technical aspects, which include network performance and terminal performance, and on non-technical aspects (not directly related to the equipment), such as point of sale, customer care, etc

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https://www.fortinet.com/resources/cyberglossary/qos-quality-of-service

Discussion (5+5 min)

- Consider that a certain developing country has 500 poorly populated cities lacking digital connectivity (no optic fibre reaching the cities, 3G mobile networks, and old, cooper infrastructure). The total population of these cities counts approx. 10% of the entire population of the country, and all of them are far from big cities and have no more than 30,000 inhabitants. 5% of the cities are in the middle of an area of preservation with strict environmental rules.
- The government has started discussing a broadband policy aimed at:
  - Increase high-speed (fiber) fixed broadband penetration from 5% to 60% in 5 years
  - Increase wireless broadband penetration from 10% to 95% in 3 years
  - Designed measures should focus on promoting adoption (demand-side) and investment (supply-side)
- Question for discussion:
  - ***What are the most suitable technologies to be deployed in this cities, both in middle-mile and last-mile, to achieve the aims of this policy?***
  - ***Should the government provide incentives for certain technological solutions, or should the policy be technology neutral?***

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III. Basics on installation and design of infrastructures

In developed economies, regulators have been increasingly supporting and incentivizing infrastructure sharing agreements.

In Europe, the EC has recommended the adoption of legislation that relies on sharing to help accelerate investment in next-generation networks.

Source: IDB, 2020; OFCOM/CSMG, 2010; EC, 2013.

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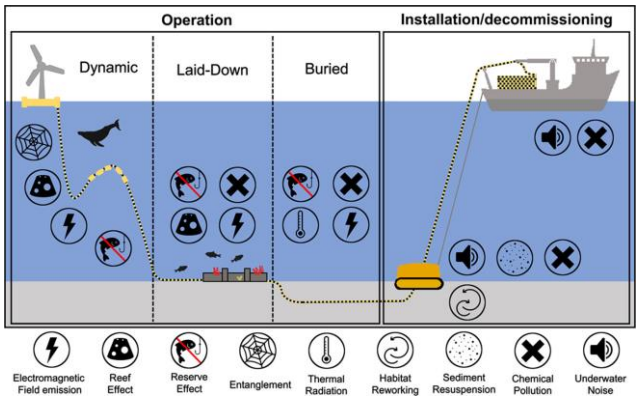
Hidden Infrastructure: Subsea optical cables impact on the marine environment



Note: this diagram refers to submarine power cables and might be considered only as reference
Source: Taormina et al., 2018

Highlights

- Installation increases noise, pollution, turbidity and physical disturbance
- Operation produces electromagnetic fields, heat, entanglement risk, pollution and reef/reserve effects
- **Overall impacts on ecosystems are considered minor or short-term**

Source: ITU, 2018

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https://www.itu.int/rec/T-REC-G.Sup41-201802-I/en

Low Impact Techniques: trenching

Technical recommendations for minimizing the impact of micro-trench construction on a roadway

	Considered Condition	Highly Recommended	Recommended	Not Recommended
Pavement layers	P1: Asphalt above natural soil		X	
	P2: Asphalt layer (5 cm)+unbounded road base (25 cm)+natural soil		X	
	P3: Asphalt layer (5 cm)+binder asphalt (10 cm)+ unbounded road base (15 cm)+natural soil	X		
Filling material	R1: Special mortar		X	
	R2: Modified asphalt + special mortar	X		
	R3: Modified asphalt	X		
	R4: Modified asphalt + gravel	X		
Micro-trench position	G1: Centerline of the road lane	X		
	G2: At the bottom of a vehicle's wheel			X
	G3: Close to a vehicle's wheel			X

Source: ITU, 2016

European Commission

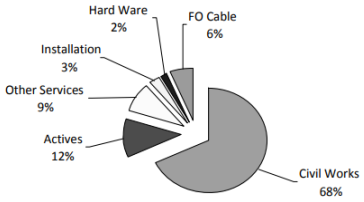
https://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-L.155-201611-I!!PDF-E&type=items

Installation and design of infrastructures

Summary of last mile technologies and deployment

Technology Issues	DSL		HFC	FTTH		
	ADSL	VDSL		A/BPON	GPON	EPON
Downstream Bandwidth	1.544~ 8 Mbps	Up to 22 Mbps	500 Kbps~ 30 Mbps	622 Mbps	2.5 Gbps	1,25 Gbps
Upstream Bandwidth	16 Kbps~ 1 Mbps	Up to 13 Mbps	100 Kbps	155~ 622 Mbps	1.25/ 2.5 Gbps	1.25 Gbps
Maintenance Cost	High		High	Low		
Installed First Cost	Low		Low	High		
Deployment Time	Fast		Fast	Slow		
Using Existing Plant	All		Most	None		

First year cost of rolling-out a new fibre network



Source: OECD, 2008

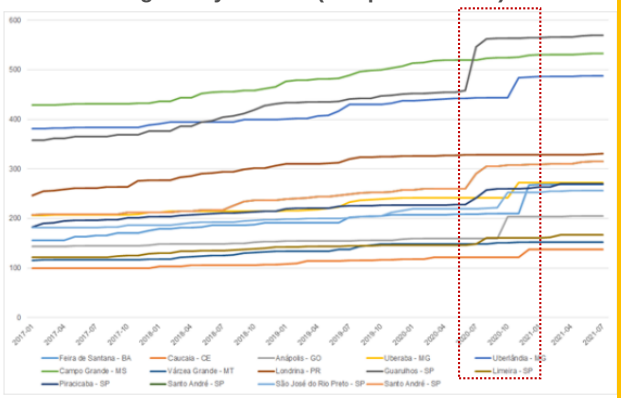
"One reason why the pace of fibre investment in the local loop is relatively slow is the cost associated with network construction, in particular for rights of way and ducts or poles, as well as the associated legal and regulatory difficulties"

European Commission

Notes:
From the perspective of costs for maintenance and installation, both Digital Subscriber Line (DSL) and Hybrid Fibre Coax (HFC) solutions have high lifetime maintenance and service costs, while featuring fairly low installation costs by using existing facilities. Even though fibre in the last mile has low maintenance and service costs, the typical fibre solution has fairly high installation costs, in particular where existing ducts or poles cannot be used. The main access architectures for fibre to end user premises are: • FTTC or FTTN (fibre to the curb or node) ñ fibre is deployed to a street cabinet or node and from there the existing copper loop (usually upgraded) is used to access the home. • FTTB (fibre to the building) ñ fibre is deployed up to the building from where copper or Ethernet can be used to connect end user premises. • FTTH (fibre to the home) ñ the local loop would simply be constituted by optical fibre from the optical distribution frame (ODF) of the service provider up to the end userís home.

Installation and Design of outdoors infrastructure

Antennas licensing after municipalities engagement in regulatory reforms (sample for Brazil)



Source: Freitas et al., 2021

Infrastructure deployment

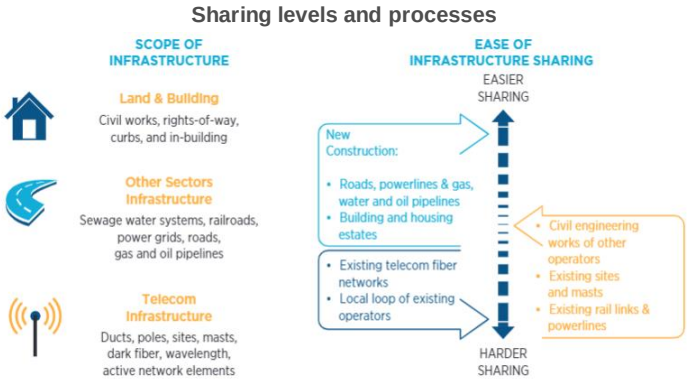
- Improved access to rights of way and reduced access costs can be achieved in a number of ways
  - Reducing barriers associated with obtaining authorization for access to and use of rights of way
  - Ensuring clarification of jurisdiction for both granting rights of way and settling disputes and coordination among the public authorities involved
- Harmonizing administrative procedures for access to rights of way and ensuring consistency in the application of these procedures across a country

European Commission

https://static1.squarespace.com/static/5a02330280bd5ebd052c8a40/t/61e6f90911f68824aa35579d/1642526997719/CPRLATAM2021+%281%29.pdf

https://www.oecd-ilibrary.org/docserver/230502835656.pdf?expires=1649773243&id=id&accname=guest&checksum=1A653B6458C1C67703949A7736CFBAAB

Infrastructure Sharing: preferential policy



Source: IDB, 2020

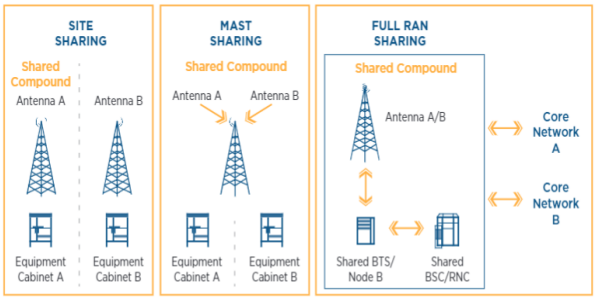
Sharing policies

- One of the instruments with the most potential to reduce the cost of networks deployment:
  - make private sector investment viable
  - can occur at different levels
  - capable of reducing the cost of investment associated with providing coverage to a particular household or population

European Commission

https://publications.iadb.org/publications/english/document/Digital-Transformation-Infrastructure-Sharing-in-Latin-America-and-the-Caribbean.pdf

Common sharing policies in the mobile network market



Source: IDB, 2020

Cost savings practices in Mobile Network

- cut broadband network deployment and expansion costs.
- It is widely agreed that civil engineering works constitute the dominant part of overall network deployment costs
- estimates as high as 80% for certain technologies
- A proper infrastructure-sharing policies allows saving between 20% and 30% of network deployment costs

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IV. Internet exchange, data centres, and cybersecurity

Internet Exchange Points (IXPs)

Internet Exchange Point Locations

Source: WB/PCH, 2022

Countries with IXPs: 149 (top 10)

United States	121	Germany	27
Russia	35	India	23
Brazil	34	France	18
Argentina	29	Japan	16
Australia	28	United Kingdom	15

Highlights

- IXPs allow domestic data traffic to be exchanged locally, without the need for the data to travel vast distances to reach overseas IXPs, incurring significant costs and time delays in the process
  - "Latin America spends around US$2 billion a year for international bandwidth—a sum that could be reduced by one-third through greater use of IXPs."

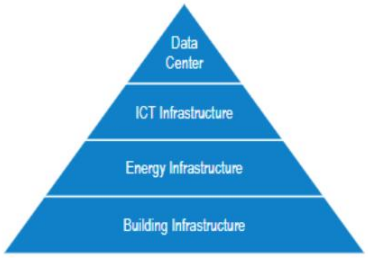
Source: WB/PCH, 2022

European Commission

https://blogs.worldbank.org/opendata/improving-data-infrastructure-helps-ensure-equitable-access-poor-people-poor-countries

Data Centers: ICT data heart

The Data Center Infrastructure Pyramid



Scale Effect

- "According to the Japan Data Center Council (JDCC), consolidation of these servers in data centers can lead to a 15 percent (250,000 tons) reduction in annual greenhouse gas emissions"
- "Virtualizing and consolidating servers in data centers would result in an estimated 40 percent (680,000 tons) reduction in emissions"

Source: IDB, 2017

Data Centers: Concept

- facility that centralizes operations and equipment
- it stores, manages, and disseminates its data
- houses servers, high-performance computers that process data and are stored in easy-to-manage and always available storage devices

European Commission

Cybersecurity: fundamentals

Global Cybersecurity Index 2020

Top Ranked

Country Name	Score	Rank
United States of America**	100	1
United Kingdom	99.54	2
Saudi Arabia	99.54	2
Estonia	99.48	3
Korea (Rep. of)	98.52	4
Singapore	98.52	4
Spain	98.52	4
Russian Federation	98.06	5
United Arab Emirates	98.06	5
Malaysia	98.06	5
Lithuania	97.93	6
Japan	97.82	7
Canada**	97.67	8
France	97.6	9
India	97.5	10
Turkey	97.49	11
Australia	97.47	12
Luxembourg	97.41	13
Germany	97.41	13
Portugal	97.32	14
Latvia	97.28	15
Netherlands**	97.05	16
Norway**	96.89	17
Mauritius	96.89	17
Brazil	96.6	18
Belgium	96.25	19
Italy	96.13	20

Bottom Ranked

Country Name	Score	Rank
Belize	10.29	159
Mali**	10.14	160
Guinea-Bissau	9.85	161
Liberia	9.72	162
Grenada	9.41	163
Lesotho	9.08	164
Nicaragua**	9	165
Solomon Islands	7.08	166
Haiti	6.4	167
Tuvalu**	5.78	168
South Sudan**	5.75	169
Dem. Rep. of the Congo	5.3	170
Afghanistan	5.2	171
Marshall Islands**	4.9	172
Timor-Leste**	4.26	173
Dominica	4.2	174
Comoros**	3.72	175
Central African Rep.**	3.24	176
Maldives**	2.95	177
Honduras**	2.2	178
Djibouti	1.73	179
Burundi	1.73	179
Eritrea**	1.73	179
Equatorial Guinea**	1.46	180
Dem. People's Rep. of Korea**	1.35	181
Micronesia*	0	182
Vatican*	0	182
Yemen*	0	182

Source: ITU, 2021

Cybersecurity: concept and strategies

- Encompasses multiple different governance, policy, operational, technical and legal aspects
- Cibersecurity strategies cover tools, policies, guidelines, risk management approaches, actions, trainings, best practices, assurance, and technologies that can be used to protect the availability, integrity, and confidentiality of assets in the connected infrastructures pertaining to government, private organizations, and citizens
  - these assets include connected computing devices, personnel, infrastructure, applications, digital services, telecommunications systems, and data in the digital-environment.

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https://ncsguide.org/the-guide/introduction/
https://www.itu.int/dms_pub/itu-d/opb/str/D-STR-GCI.01-2021-PDF-E.pdf

Discussion (10+10 min)

- Consider that a certain developing country has 500 poorly populated cities lacking digital connectivity (no optic fibre reaching the cities, 3G mobile networks, and old, cooper infrastructure). The total population of these cities counts approx. 10% of the entire population of the country, and all of them are far from big cities and have no more than 30,000 inhabitants. 5% of the cities are in the middle of an area of preservation with strict environmental rules.
- The government has started discussing a broadband policy aimed at:
  - Increase high-speed (fiber) fixed broadband penetration from 5% to 60% in 5 years
  - Increase wireless broadband penetration from 10% to 95% in 3 years
  - Designed measures should focus on promoting adoption (demand-side) and investment (supply-side)
- Question for discussion:
  - ***What should be the main elements of this broadband policy? Please discuss and detail what kind of public incentives should be offered to promote deployment of transport networks, as well as access networks on these cities.***

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Part 1: Quiz

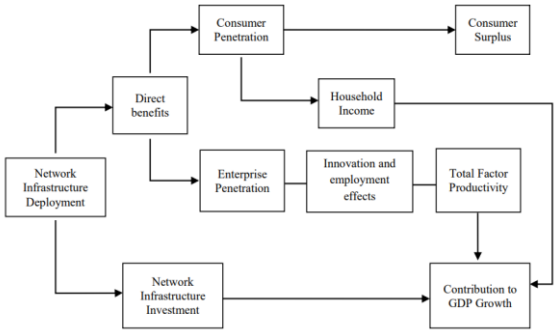
Part 2 - Implementation of Digital Connectivity

Financing the digital connectivity

I. Doing business in developing countries

Economic effects of digital communications

The economic impact of digital



Source: Katz and Berry, 2014

Economic effects of digital communications take place via:

- additional job creation leads to multiplier effects which ripple through the economy
- positive externalities which arise for both businesses and consumers, particularly in terms of time savings and efficiency
- Increasing in real household income, as well as produce a consumer surplus

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Quick reminder of the demand side drivers

Source: World Bank, 2019

Closing the Digital Divide

- Most investment in the past decade was focused on larger cities with relatively high-density households and businesses.
  - half of the globe's population—about four billion people—are not yet connected to the Internet.
- Most governments around the world are now addressing the issue of connectivity to rural and other underserved areas in their priority policy agendas.

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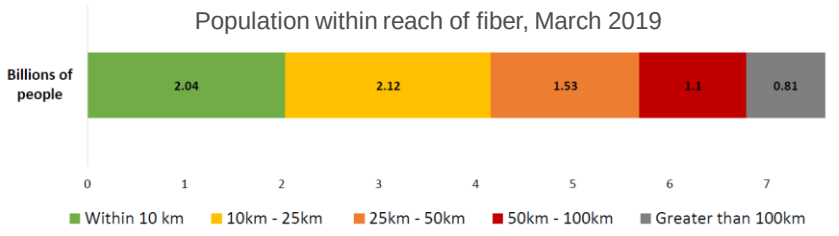
https://openknowledge.worldbank.org/bitstream/handle/10986/31072/132845-7-12-2018-17-20-11-InnovativeBusinessModels.pdf

The increasing marginal cost



Source: ITU, 2020

- The marginal cost to connect the unconnected people increases as:
  - the distances to reach them increase
  - The population density is lower
  - The economic attractiveness is lower

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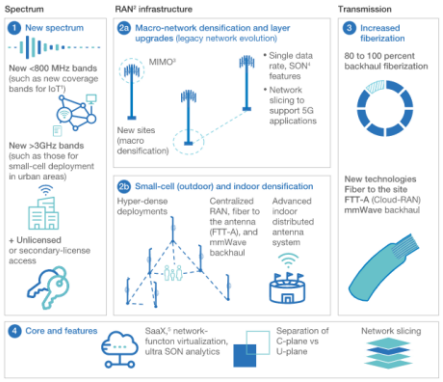
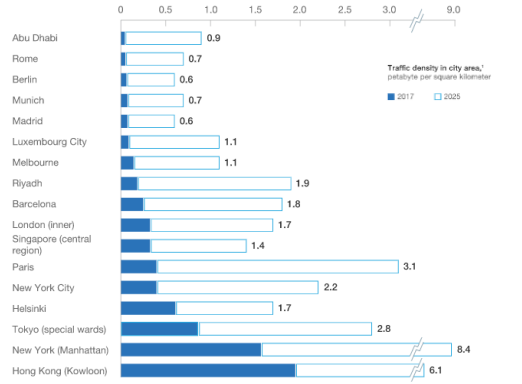
The inevitable growth of infrastructure cost

Growing demand related to 5G use cases will trigger investment across all network domains.



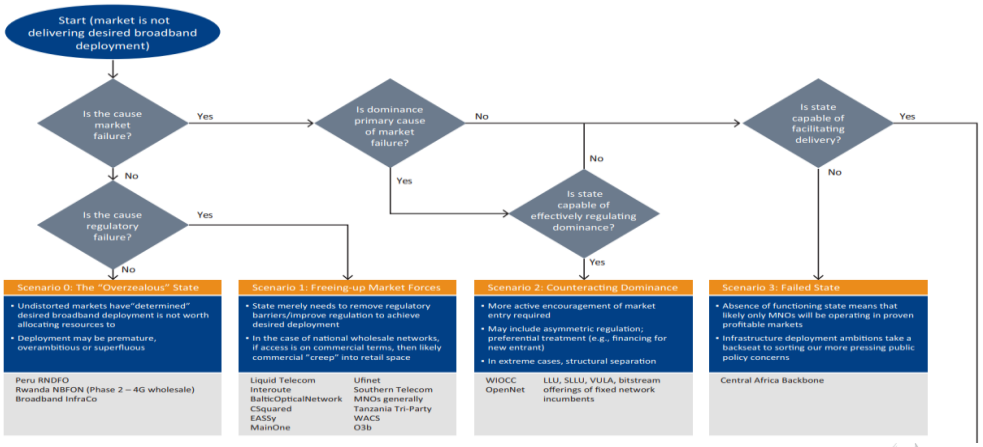
Network traffic density is growing in urban locations



Source: McKinsey's, 2020

https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/the-road-to-5g-the-inevitable-growth-of-infrastructure-cost

Decision-Tree for scenarios for the state's role in infrastructure deployment



Source: World Bank, 2018

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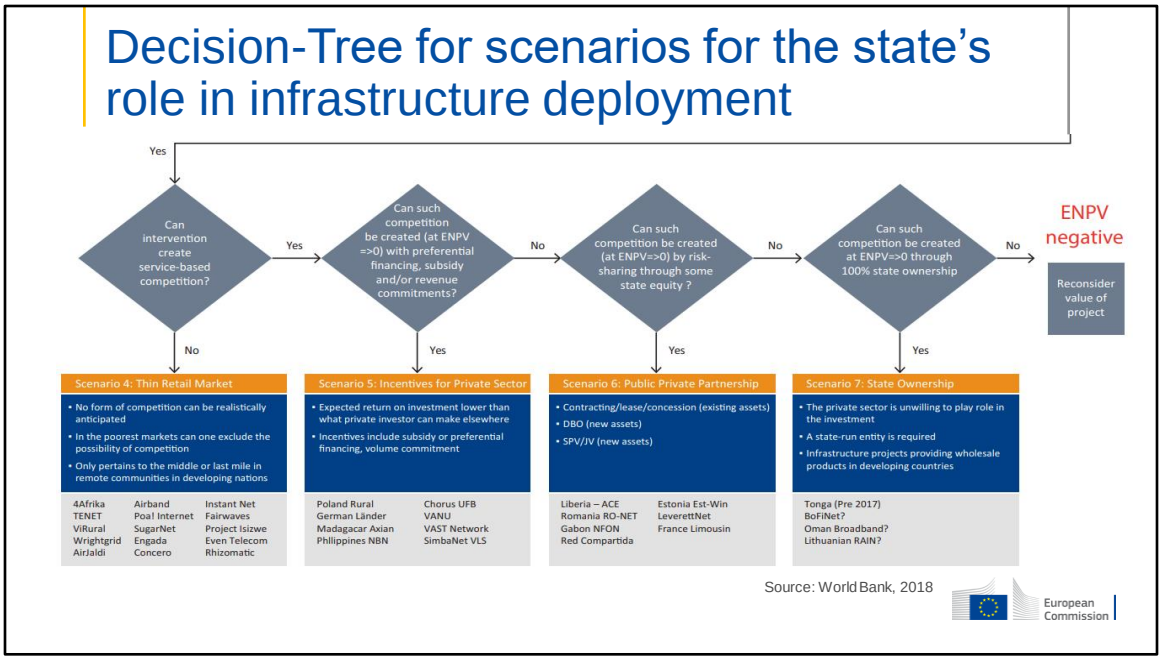
https://openknowledge.worldbank.org/bitstream/handle/10986/31072/132845-7-12-2018-17-20-11-InnovativeBusinessModels.pdf

Notes:

- lessons for policy makers seeking to intervene to deploy in underserved areas.
- Decision-making tool (seven scenarios plus a "null" scenario):
    - Null Scenario:
        - the state should reconsider any proposed intervention. Where there is no demonstrable market or regulatory failure to address, state action is generally not justified. There are at least three examples in the list of reviewed projects where the state may have been unnecessarily ambitious in its objectives—the second phase of Rwanda NBFON (involving the pursuit of a single wholesale mobile network for 4G), Peru RNDOFO, and South Africa's Broadband InfraCo. In the latter two, state investment was made in national backbones in markets in which the private sector was capable of delivering infrastructure on its own.
    - Scenario 1:
        - results when there is no inherent market failure, but

counterproductive regulation, unnecessary legal constraints, or unduly burdensome financial obligations are imposed by the state. In this scenario, the state's role is simply to eliminate or minimize the self-created cause of infrastructure inadequacy. In most cases, this amounts to improving licensing—simply authorizing the entry of new players, ensuring spectrum is available, and so on.

- Scenario 2:
    - is the case of market failure primarily arising from dominance in the market. Here more active regulatory intervention may be required. This may take the form of more active encouragement of private sector competitors, for example, the creation of WIOCC in the crossborder market of East Africa, mandated access of dominant player networks, or more radical solutions such as structural separation. Before addressing other, more interventionist, roles that the state may play in infrastructure development, the state has to answer the question of whether it is capable of taking on such a role to create missing markets or infrastructure. The vast majority of states are in some way capable of playing a constructive role;
- Scenario 3:
    - states that have severe institutional issues, or an inability to commit to required policy or provide appropriate leadership.
    - deals with fundamental governance weaknesses must be a central part of any development program implemented. Consistent with the principle of promoting competition, the next question is whether a more active role for the state can be used to create service-based competition.



ENPV Economic net present value

SPV (Special purpose vehicle) and JV (Joint ventures) are types of PPP.

The SPV allows for the segregation of all assets and liabilities linked to the private provision of services.

Joint ventures between the public and private sectors in PPP arise when a contracting authority may require to have an equity stake ("shares") in the project company

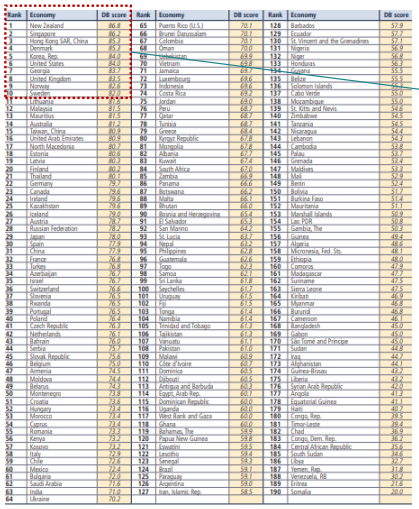
https://openknowledge.worldbank.org/bitstream/handle/10986/31072/132845-7-12-2018-17-20-11-InnovativeBusinessModels.pdf

Notes:

- **Scenario 4:**
  - the market cannot even support service-based competition

    - it is probably very thin. These cases tend to be remote local markets. There are a number of innovative technologies and business models discussed in this report that address these particular circumstances.
- *[Scenario 5, 6, and 7 address state action that is progressively more interventionist:*
    - *In each case, the state's financial commitments should be justified on the basis of a robust cost-benefit analysis.]*
- **Scenario 5:**
    - is the case where the state can limit its intervention to subsidy, preferential financing, or sales commitments, which offset low or uncertain nonstate revenues. In this case, the state can stay out of the management or ownership of the entity undertaking the project. Ideally, incentives would be competed for through an appropriately structured tender process.
- **Scenario 6:**
    - represents those cases in which the subsidy required to interest the private sector in taking up the opportunity is too high for the state to afford. In these cases, the state must take on more of the project risk in order to attract the private sector.
- **Scenario 7:**
    - is limited to those instances in which the state cannot build a sufficiently attractive offer of financial incentives and risk-sharing to interest the private sector. This would be a very small set of cases indeed. Of all the projects reviewed in this report, arguably, only one may have met this criterion.

Insights on Countries' risk: the ease of doing business index- top scores



Rank	Economy	DB score	Rank	Economy	DB score	Rank	Economy	DB score
1	New Zealand	86.8	65	Puerto Rico (U.S.)	70.1	128	Barbados	57.9
2	Singapore	86.2	66	Brunei Darussalam	70.1	129	Ecuador	57.7
3	Hong Kong SAR, China	85.3	67	Colombia	70.1	130	St. Vincent and the Grenadines	57.1
4	Denmark	85.3	68	Oman	70.0	131	Nigeria	56.9
5	Korea, Rep.	84.0	69	Uzbekistan	69.9	132	Niger	56.8
6	United States	84.0	70	Vietnam	69.8	133	Honduras	56.3
7	Georgia	83.7	71	Jamaica	69.7	134	Guyana	55.5
8	United Kingdom	83.5	72	Luxembourg	69.6	135	Belize	55.5
9	Norway	82.6	73	Indonesia	69.6	136	Solomon Islands	55.2
10	Sweden	82.0	74	Costa Rica	69.2	137	Cabo Verde	55.0
11	Lithuania	81.8	75	Jordan	69.0	138	Mozambique	55.0
12	Malaysia	81.5	76	Peru	68.7	139	St. Kitts and Nevis	54.6
13	Mauritius	81.5	77	Qatar	68.7	140	Zimbabwe	54.5
14	Australia	81.4	78	Tunisia	68.7	141	Tanzania	54.5
15	Taiwan, China	80.9	79	Greece	68.4	142	Nicaragua	54.4
16	United Arab Emirates	80.9	80	Kyrgyz Republic	67.8	143	Lebanon	54.3
17	North Macedonia	80.7	81	Mongolia	67.8	144	Cambodia	53.8
18	Estonia	80.6	82	Albania	67.7	145	Palau	53.7
19	Latvia	80.3	83	Kuwait	67.4	146	Grenada	53.4
20	Finland	80.2	84	South Africa	67.0	147	Maldives	53.2
21	Thailand	80.1	85	Zambia	66.9	148	Mali	52.9
22	Germany	79.7	86	Panama	66.6	149	Benin	52.4
23	Canada	79.6	87	Botswana	66.2	150	Bolivia	51.7
24	Ireland	79.6	88	Malta	66.1	151	Burkina Faso	51.4
25	Kazakhstan	79.6	89	Bhutan	66.0	152	Mauritania	51.1
26	Iceland	79.0	90	Bosnia and Herzegovina	65.4	153	Marshall Islands	50.9
27	Austria	78.7	91	El Salvador	65.2	154	Lao PDR	50.8
28	Russian Federation	78.2	92	San Marino	64.2	155	Gambia, The	50.3
29	Japan	78.0	93	St. Lucia	63.7	156	Guinea	49.4
30	Spain	77.9	94	Nepal	63.2	157	Algeria	48.6
31	China	77.9	95	Philippines	62.8	158	Micronesia, Fed. Sts.	48.1
32	France	76.8	96	Guatemala	62.6	159	Ethiopia	48.0
33	Turkey	76.8	97	Togo	62.3	160	Comoros	47.9
34	Azerbaijan	76.7	98	Samoa	62.1	161	Madagascar	47.7
35	Israel	76.7	99	Sri Lanka	61.8	162	Suriname	47.5
36	Switzerland	76.6	100	Seychelles	61.7	163	Sierra Leone	47.5
37	Slovenia	76.5	101	Uruguay	61.5	164	Kiribati	46.9
38	Rwanda	76.5	102	Fiji	61.5	165	Myanmar	46.8
39	Portugal	76.3	103	Tonga	61.4	166	Burundi	46.8
40	Poland	76.4	104	Namibia	61.4	167	Cameroon	46.1
41	Czech Republic	76.3	105	Trinidad and Tobago	61.3	168	Bangladesh	45.0
42	Netherlands	76.1	106	Tajikistan	61.3	169	Gabon	45.0
43	Bahrain	76.0	107	Vanuatu	61.1	170	São Tomé and Príncipe	45.0
44	Serbia	75.7	108	Pakistan	61.0	171	Sudan	44.8
45	Slovak Republic	75.6	109	Malawi	60.9	172	Iraq	44.7
46	Belgium	75.0	110	Côte d'Ivoire	60.7	173	Afghanistan	44.1
47	Armenia	74.5	111	Dominica	60.5	174	Guinea-Bissau	43.2
48	Moldova	74.4	112	Djibouti	60.5	175	Liberia	43.2
49	Belarus	74.3	113	Antigua and Barbuda	60.3	176	Syrian Arab Republic	42.0
50	Montenegro	73.8	114	Egypt, Arab Rep.	60.1	177	Angola	41.9
51	Croatia	73.6	115	Dominican Republic	60.0	178	Equatorial Guinea	41.1
52	Hungary	73.5	116	Uganda	60.0	179	Haiti	40.7
53	Morocco	73.4	117	West Bank and Gaza	60.0	180	Congo, Rep.	39.5
54	Cyprus	73.4	118	Ghana	60.0	181	Timor-Leste	39.4
55	Romania	73.2	119	Bahamas, The	59.9	182	Chad	36.9
56	Kenya	73.2	120	Papua New Guinea	59.8	183	Congo, Dem. Rep.	36.2
57	Kosovo	73.1	121	Eswatini	59.5	184	Central African Republic	35.6
58	Italy	72.9	122	Lesotho	59.4	185	South Sudan	34.6
59	Chile	72.6	123	Senegal	59.3	186	Libya	32.7
60	Mexico	72.4	124	Brazil	59.1	187	Yemen, Rep.	31.8
61	Bulgaria	72.0	125	Paraguay	59.1	188	Venezuela, RB	30.2
62	Saudi Arabia	71.6	126	Argentina	59.0	189	Eritrea	21.6
63	India	71.0	127	Iran, Islamic Rep.	58.5	190	Somalia	20.0
64	Ukraine	70.2						

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1	New Zealand	*86.8*
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3	Hong Kong SAR, China	*85.3*
4	Denmark	*85.3*
5	Korea, Rep.	*84.0*
6	United States	*84.0*
7	Georgia	*83.7*
8	United Kingdom	*83.5*
9	Norway	*82.6*
10	Sweden	*82.0*

Some highlights

- Since 2003/04, the 20 best-performing economies have carried out a total of 464 regulatory changes, suggesting that even the gold standard setters have room to improve their business climates
- More than half of the economies in the top-20 cohort are from the OECD high-income group

European Commission

Source: WB, 2021
Disclaimer: World Bank Group to Discontinue Doing Business Report

Insights on Countries' risk: the ease of doing business index- bottom scores

Rank	Economy	DB score	Rank	Economy	DB score	Rank	Economy	DB score
1	New Zealand	86.8	65	Puerto Rico (U.S.)	70.1	128	Barbados	57.9
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4	Denmark	85.3	68	Oman	70.0	131	Nigeria	56.9
5	Korea, Rep.	84.0	69	Uzbekistan	69.9	132	Niger	56.8
6	United States	84.0	70	Vietnam	69.8	133	Honduras	56.3
7	Georgia	83.7	71	Jamaica	69.7	134	Guyana	55.5
8	United Kingdom	83.5	72	Luxembourg	69.6	135	Belize	55.5
9	Norway	82.6	73	Indonesia	69.6	136	Solomon Islands	55.3
10	Sweden	82.0	74	Costa Rica	69.2	137	Cabo Verde	55.0
11	Lithuania	81.6	75	Jordan	69.0	138	Mozambique	55.0
12	Malaysia	81.5	76	Peru	68.7	139	St. Kitts and Nevis	54.6
13	Mauritius	81.5	77	Qatar	68.7	140	Zimbabwe	54.5
14	Australia	81.4	78	Tunisia	68.7	141	Tanzania	54.5
15	Taiwan, China	80.9	79	Greece	68.4	142	Nicaragua	54.4
16	United Arab Emirates	80.9	80	Kyrgyz Republic	67.8	143	Lebanon	54.3
17	North Macedonia	80.7	81	Mongolia	67.8	144	Cambodia	53.8
18	Estonia	80.6	82	Albania	67.7	145	Palau	53.7
19	Latvia	80.3	83	Kuwait	67.4	146	Grenada	53.4
20	Finland	80.2	84	South Africa	67.0	147	Maldives	53.2
21	Thailand	80.1	85	Zambia	66.9	148	Mali	52.9
22	Germany	79.7	86	Panama	66.6	149	Benin	52.4
23	Canada	79.6	87	Botswana	66.2	150	Bolivia	51.7
24	Ireland	79.6	88	Malta	66.1	151	Burkina Faso	51.4
25	Kazakhstan	79.6	89	Bhutan	66.0	152	Mauritania	51.3
26	Iceland	79.0	90	Bosnia and Herzegovina	65.4	153	Marshall Islands	50.9
27	Austria	78.7	91	El Salvador	65.2	154	Lao PDR	50.8
28	Russian Federation	78.2	92	San Marino	64.2	155	Gambia, The	50.3
29	Japan	78.0	93	St. Lucia	63.7	156	Guinea	49.4
30	Spain	77.9	94	Nepal	63.2	157	Algeria	48.6
31	China	77.9	95	Philippines	62.8	158	Micronesia, Fed. Sts.	48.1
32	France	76.8	96	Guatemala	62.6	159	Ethiopia	48.0
33	Turkey	76.8	97	Togo	62.3	160	Comoros	47.9
34	Azerbaijan	76.7	98	Samoa	62.1	161	Madagascar	47.7
35	Israel	76.7	99	Sri Lanka	61.8	162	Suriname	47.5
36	Switzerland	76.6	100	Seychelles	61.7	163	Sierra Leone	47.5
37	Slovenia	76.5	101	Uruguay	61.5	164	Kiribati	46.9
38	Rwanda	76.5	102	Fiji	61.5	165	Myanmar	46.8
39	Portugal	76.3	103	Tonga	61.4	166	Burundi	46.8
40	Poland	76.4	104	Namibia	61.4	167	Cameroon	46.1
41	Czech Republic	76.3	105	Trinidad and Tobago	61.3	168	Bangladesh	45.0
42	Netherlands	76.1	106	Tajikistan	61.3	169	Gabon	45.0
43	Bahrain	76.0	107	Vanuatu	61.1	170	São Tomé and Príncipe	45.0
44	Serbia	75.7	108	Pakistan	61.0	171	Sudan	44.8
45	Slovak Republic	75.6	109	Malawi	60.9	172	Iraq	44.7
46	Belgium	75.0	110	Côte d'Ivoire	60.7	173	Afghanistan	44.1
47	Armenia	74.5	111	Dominica	60.5	174	Guinea-Bissau	43.2
48	Moldova	74.4	112	Djibouti	60.5	175	Liberia	43.2
49	Belarus	74.3	113	Antigua and Barbuda	60.3	176	Syrian Arab Republic	42.0
50	Montenegro	73.8	114	Egypt, Arab Rep.	60.1	177	Angola	41.9
51	Croatia	73.6	115	Dominican Republic	60.0	178	Equatorial Guinea	41.1
52	Hungary	73.5	116	Uganda	60.0	179	Haiti	41.1
53	Morocco	73.4	117	West Bank and Gaza	60.0	180	Congo, Rep.	39.5
54	Cyprus	73.4	118	Ghana	60.0	181	Timor-Leste	39.4
55	Romania	73.2	119	Bahamas, The	59.9	182	Chad	36.9
56	Kenya	73.2	120	Papua New Guinea	59.8	183	Congo, Dem. Rep.	36.2
57	Kosovo	73.1	121	Eswatini	59.5	184	Central African Republic	35.6
58	Italy	72.9	122	Lesotho	59.4	185	South Sudan	34.6
59	Chile	72.6	123	Senegal	59.3	186	Libya	32.7
60	Mexico	72.4	124	Brazil	59.1	187	Yemen, Rep.	31.8
61	Bulgaria	72.0	125	Paraguay	59.1	188	Venezuela, RB	30.2
62	Saudi Arabia	71.6	126	Argentina	59.0	189	Eritrea	21.6
63	India	71.0	127	Iran, Islamic Rep.	58.5	190	Somalia	20.0
64	Ukraine	70.2						

Some highlights

- most economies in the bottom 20 are from the Sub-Saharan Africa region
- it takes nearly six times longer on average to start a business in the economies ranked in the bottom 50 than it does in the top 20

180	Congo, Rep.	39.5
181	Timor-Leste	39.4
182	Chad	36.9
183	Congo, Dem. Rep.	36.2
184	Central African Republic	35.6
185	South Sudan	34.6
186	Libya	32.7
187	Yemen, Rep.	31.8
188	Venezuela, RB	30.2
189	Eritrea	21.6
190	Somalia	20.0

Source: WB, 2021
Disclaimer: World Bank Group to Discontinue Doing Business Report

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Classification of risk on infrastructure assets

<table>
<tr><th>Risk Categories</th><th>Development Phase</th><th>Construction Phase</th><th>Operation Phase</th><th>Termination Phase</th></tr>
<tr><td rowspan="8">Political and regulatory</td><td>Environmental review</td><td>Cancellation of permits</td><td rowspan="2">Change in tariff regulation</td><td>Contract duration</td></tr>
<tr><td rowspan="2">Rise in pre-construction costs (longer permitting process)</td><td rowspan="2">Contract renegotiation</td><td>Decommission</td></tr>
<tr><td>Asset transfer</td></tr>
<tr><td colspan="3">Currency convertibility</td></tr>
<tr><td colspan="4">Change in taxation</td></tr>
<tr><td colspan="4">Social acceptance</td></tr>
<tr><td colspan="4">Change in regulatory or legal environment</td></tr>
<tr><td colspan="4">Enforceability of contracts, collateral and security</td></tr>
<tr><td rowspan="5">Macroeconomic and business</td><td>Prefunding</td><td colspan="3">Default of counterparty</td></tr>
<tr><td colspan="2" rowspan="3">Financing availability</td><td colspan="2">Refinancing risk</td></tr>
<tr><td colspan="2">Liquidity</td></tr>
<tr><td colspan="2">Volatility of demand/market risk</td></tr>
<tr><td colspan="4">Inflation</td></tr>
<tr><td colspan="4">Real interest rates</td></tr>
<tr><td colspan="4">Exchange rate fluctuation</td></tr>
<tr><td rowspan="6">Technical</td><td colspan="3">Governance and management of the project</td><td rowspan="4">Termination value different from expected</td></tr>
<tr><td colspan="3">Environmental</td></tr>
<tr><td>Project feasibility</td><td rowspan="2">Construction delays and cost overruns</td><td rowspan="2">Qualitative deficit of the physical structure/ service</td></tr>
<tr><td>Archaeological</td></tr>
<tr><td colspan="4">Technology and obsolescence</td></tr>
<tr><td colspan="4">Force majeure</td></tr>
</table>

Source: ITU, 2021

Classification of risks linked to infrastructure:

- technical and operational risks are exposed to different levels of political and regulatory risk
- exist throughout the value chain and lifecycle of a project
- highest at development phase when the costs are highest, at construction phase, operation phase, and exit or termination phase.
- may require several funding models over its lifecycle

European Commission

https://www.itu.int/en/ITU-D/Conferences/GSR/2021/Documents/Publications/GSR21_Financing%20Universal%20Access%20To%20Digital%20Technologies%20And%20Services.pdf

Discussion (5+5 min)

- Consider that a certain developing country has 500 poorly populated cities lacking digital connectivity (no optic fibre reaching the cities, 3G mobile networks, and old, cooper infrastructure). The total population of these cities counts approx. 10% of the entire population of the country, and all of them are far from big cities and have no more than 30,000 inhabitants. 5% of the cities are in the middle of an area of preservation with strict environmental rules.
- The government has started discussing a broadband policy aimed at:
  - Increase high-speed (fiber) fixed broadband penetration from 5% to 60% in 5 years
  - Increase wireless broadband penetration from 10% to 95% in 3 years
  - Designed measures should focus on promoting adoption (demand-side) and investment (supply-side)
- Question for discussion:
  - ***Re-visit your policy design in light of the decision-tree for governmental intervention. Please, draw some assumptions and discuss which scenario(s) and interventions should be more suitable to achieve the policy goals described above.***

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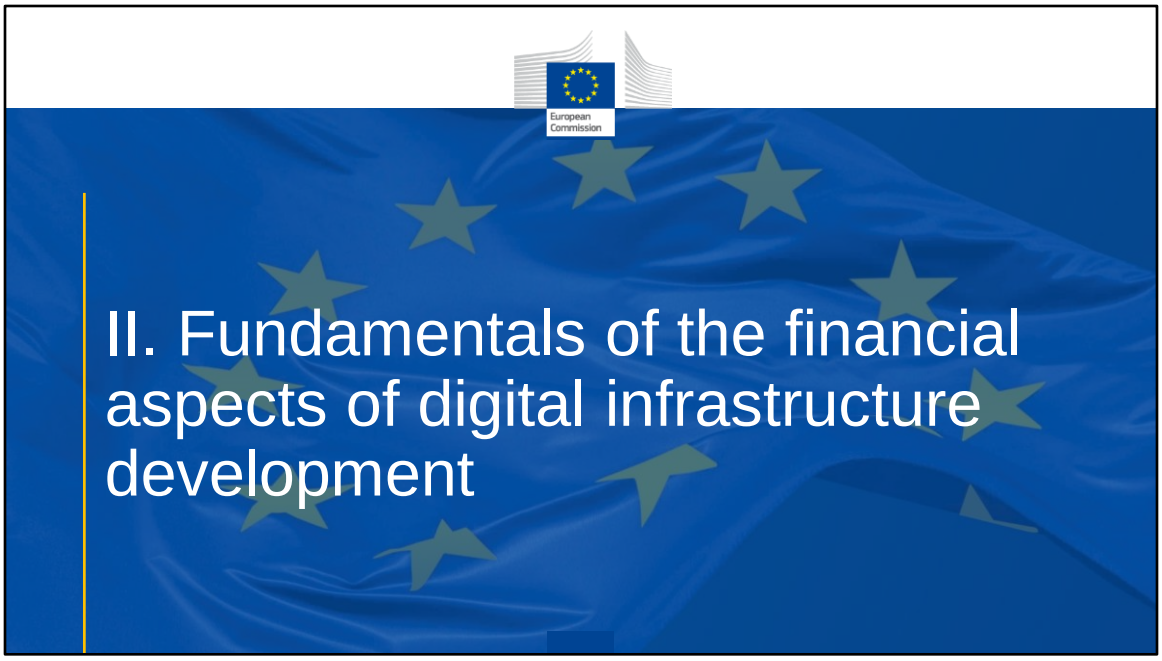


II. Fundamentals of the financial aspects of digital infrastructure development

Structure of the Internet

Tier 1

- Large ISP´s directly connected to internet backbone
- Connected to international Gateway

Tier 2

Medium size ISP´s having peers with some networks

Pays IP transits/settlements to reach someparts of the network

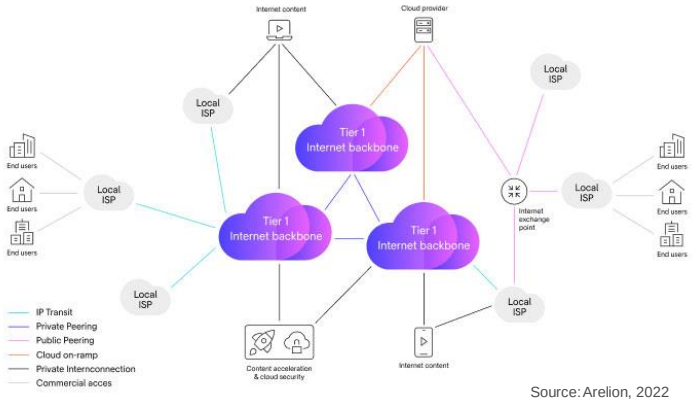
Tier 3

- Local ISP´s buying services from Tier 1 and Tier 2 ISP´s
- No backbone
- Focused only on retail market

European Commission

The Tier 1 networks: largest providers

Service providers (Tier 1) in the Internet ecosystem

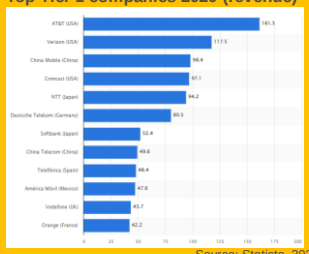


Source: Arelion, 2022

Highlights

- The largest providers are known as Tier 1 networks.

Top Tier 1 companies 2020 (revenue)



Source: Statista, 2022

- They are positioned at the top of the Internet ecosystem
- Tier 1 networks exchange Internet backbone traffic on the basis of privately negotiated interconnection agreements

European Commission

https://www.arelion.com/knowledge-hub/what-is-guides/what-is-the-Intern

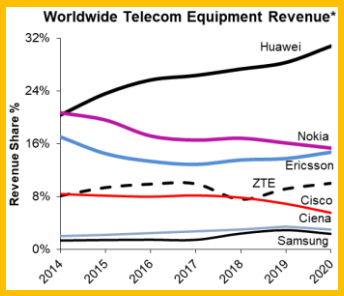
https://www.statista.com/statistics/221382/revenue-of-top-30-global-telecommunication-operators/et-backbone.html

Suppliers: telecommunications vendors

2005 GSM/CDMA	2010 3G	2015 4G	2020 5G
Alcatel	Alcatel-Lucent	Alcatel-Lucent	Ericsson
Ericsson	Ericsson	Ericsson	Fujitsu
Fujitsu	Fujitsu	Fujitsu	Huawei
Huawai	Huawei	Huawei	NEC
NEC	NEC	NEC	Nokia
Lucent	Matsushita	Nokia	Samsung
Matsushita	Motorola	Samsung	ZTE
Motorola	Nokia	ZTE	
Nokia	Siemens		
Nortel	Panasonic		
Panasonic	Samsung		
Samsung	ZTE		
Siemens			
ZTE			
14	11	8	7

Source: Freitas, 2021

World Revenue Share per vendor



- oligopolistic competition imposes additional pressure on issues such as cost, innovation, and final price of consumers.

Source: EETimes, 2021

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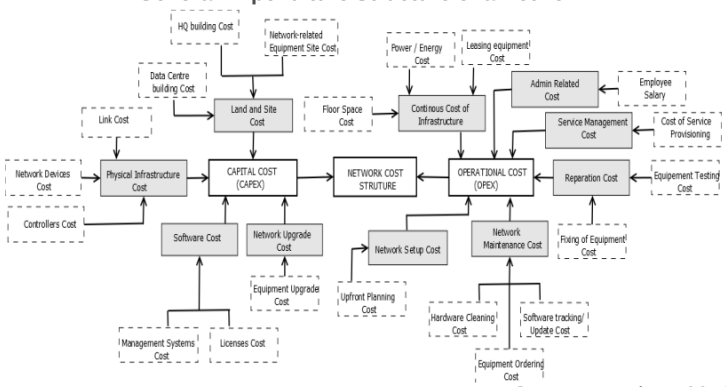
https://www.eetasia.com/huawei-maintains-lead-in-global-communications-equipment-market/

Costs of telecommunication infrastructures

General Expenditure Structure of a Network



Source: Karakus, 2018

- dashed rectangles represent the input costs and actions to the corresponding expenditure groups represented as rounded rectangles.

Highlights

- cost structure comprises capital expenditures and operational expenses of any wireline and wireless network
- network cost model is a tool to estimate the cost values of network equipment's and related network elements
- ISP and network operators develop cost models for their networks to obtain accurate network cost information

European Commission

Business models: attributes and success measures

Primary attributes	Success measures
• The market structure in which the deployment operates • The economic context (for example, strength of demand) • The regulatory and policy efficacy, that is, how well policy, regulation and enforcement align with objectives of the deployment • The degree and nature of infrastructure-sharing • The business model, which may include one of a number of approaches	• Geographic reach of network • Increase in installed bandwidth; • Volume of national traffic • Utilization of network relative to legacy network(s) replaced • Prices of network services relative to legacy prices and affordability • Investment and unit investment (for example, per fiber kilometer) • Performance to plan.

General recommendations

- Limited, incremental state intervention
- Private investment first
- Minimize regulatory failure
- Consensus on a coherent vision, political will, and leadership.
- Governments should take a sober view of what activity it can credibly and reliably carry out.
- Promoting competition

Source: WB, 2018

European Commission

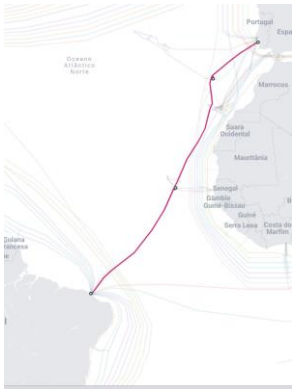
https://openknowledge.worldbank.org/bitstream/handle/10986/31072/132845-7-12-2018-17-20-11-InnovativeBusinessModels.pdf

Notes:
GENERAL RECOMMENDATIONS There are five key principles that should form the basis of any policy for promoting broadband deployment: • Limited, incremental state intervention. Governments should intervene only in cases of clear market failure and only to the extent necessary to overcome market failure and complement private investment. In such cases, the government should attempt to achieve its objectives through the least disruptive means possible and should only increase the scale or degree of intervention if the market failure proves persistent. • Minimize regulatory failure. Governments can take many actions to encourage infrastructure deployment that do not require any direct intervention in the market. The state should first consider the result of measures to obviate or minimize regulatory failure before it concludes that market failure exists. • Consensus on a coherent vision, political will, and leadership. Intervention should be based on clear policy objectives for the sector, be conducted with commitment on the part of leadership, and flow through to

regulation consistent with the policy objectives. • Governments should take a sober view of what activity it can credibly and reliably carry out. All states will have limits as to the skill sets, finances, and legal authority, among others, available to actively participate in infrastructure deployment. Governments should assess these capabilities and craft their participation accordingly. • Promoting competition. Government intervention should be directed at increasing competition, through service-based competition when infrastructure competition is not viable. When infrastructure competition is not feasible, governments should generally support open access wholesale arrangements.

Case Study: The EU-Latin America submarine cable (BELLA Cable)

EllaLink (Cable Length: 6,200 km)



EU investment aims at:

- ensuring a very high-capacity bandwidth for research and education.
  - Such as: make it easier for researchers in Latin America to access the Large Hadron Collider in Geneva (Switzerland), and for researchers in Europe to access the Astronomical and Cosmic Ray Observatories in the Atacama Desert (northern Chile).
- developing the broadband infrastructure in Latin America to make the most out of the new transatlantic connection.
- Today Latin America relies on undersea cables going to the U.S. to carry almost all (85-90%) of its communications to Europe.

Source: EU, 2020

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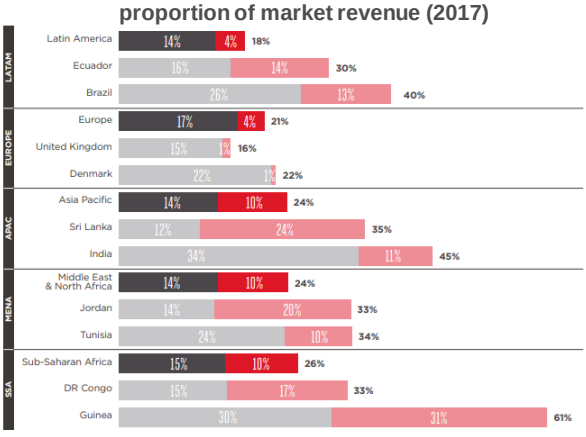
https://digital-strategy.ec.europa.eu/en/news/eu-latin-america-submarine-cable-boosting-connection-between-our-continents

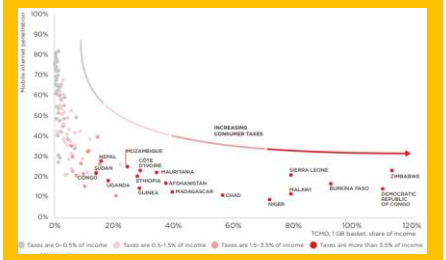
Taxation: sector-specific taxes reduce affordability and investment

General and sector-specific taxes and fees as a proportion of market revenue (2017)



Source: GSMA, 2018

Total cost of mobile ownership for 1 GB (as a proportion of income) and mobile internet penetration (2017)



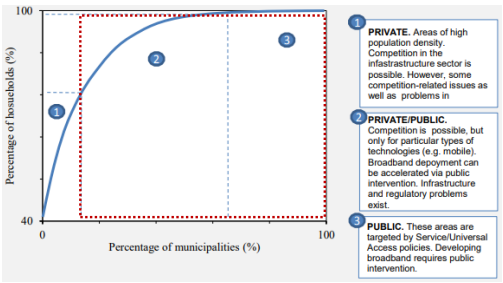
"For countries where taxes account for more than 3.5% of consumers' incomes, reducing taxes could be an important strategy to improve mobile connectivity"

European Commission

https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/02/Enabling_Rural_Coverage_English_February_2018.pdf

Financing instruments and channels

Types of interventions



Source: UN,2017

Private financing mechanisms

Modes		Infrastructure Finance Instruments		Market Vehicles
Asset Category	Instrument	Infrastructure Project	Corporate Balance Sheet / Other Entities	Capital Pool
Fixed Income	Bonds	Project Bonds	Corporate Bonds, Green Bonds	Bond Indices, Bond Funds, ETFs
		Municipal, Sub-sovereign bonds		
		Green Bonds, Sukuk	Subordinated Bonds	
	Loans	Direct/Co-Investment lending to Infrastructure project, Syndicated Project Loans	Direct/Co-investment lending to infrastructure corporate	Debt Funds (GPs)
			Syndicated Loans, Securitized Loans (ABS), CLOs	Loan Indices, Loan Funds
Mixed	Hybrid	Subordinated Loans/Bonds, Mezzanine Finance	Subordinated Bonds, Convertible Bonds, Preferred Stock	Mezzanine Debt Funds (GPs), Hybrid Debt Funds
Equity	Listed	YieldCos	Listed infrastructure & utilities stocks, Closed-end Funds, REITs, IITs, MLPs	Listed Infrastructure Equity Funds, Indices, trusts, ETFs
	Unlisted	Direct/Co-Investment in infrastructure project equity, PPP	Direct/Co-Investment in infrastructure corporate equity	Unlisted Infrastructure Funds

Source: OECD,2015

European Commission

https://www.unescap.org/sites/default/files/Universal%20Access%20and%20Service%20Funds.pdf
https://www.oecd.org/finance/private-pensions/Infrastructure-Financing-Instruments-and-Incentives.pdf

Notes:

- From an investor's perspective, the instruments and pooling mechanisms selected for investment will depend on the nature of the asset (debt, equity, listed or unlisted), regulatory and tax considerations, and on how the investors have defined and allocated infrastructure in their portfolios, based on their asset/liability framework. Other considerations are diversification and level of investor sophistication: small investors with limited resources and small amounts of capital allocated to infrastructure are limited to capital pool channels and corporate investments while large funds may be able to commit capital directly to projects.

- The instrument column divides the asset categories into the principal modes – fixed income into bonds and loans, equity into listed and unlisted shares, and

hybrids being combinations of both. These instruments can further define the level of control in an investment, liquidity and the types of contractual claims on cash flows.

- Together, loans and bonds form the largest categories of infrastructure finance, mirroring the broader fixed income markets: global debt markets are the deepest capital markets in the world. Debt instruments can be structured to have long-term maturities that extend over the life of long-term assets. Debt financing can be provided through multiple instruments; debt instruments can take the form of direct loans held on the balance sheets of financial institutions or may be structured for resale to investors or distribution in markets, be it private markets (such as private-placement debt) or public markets through registered corporate and government bonds. Furthermore, financiers of infrastructure projects can take advantage of clientele effects8 in debt markets: issues can be tailored to fit the demands and preferences of certain investors such as pension funds and insurance companies thereby broadening the appeal of infrastructure finance to a larger potential pool of capital.
- Hybrid instruments such as mezzanine finance are debt instruments with equity-like participation, thus forming a bridge between debt and equity instruments.
- Equity finance refers to all financial resources that are provided to firms in return for an ownership interest. Investors may sell their shares in the firm/project, if a market exists, or they may get a share of the proceeds if the asset is sold. They are crucial in the financing of infrastructure investments as the providers of risk capital to initiate a project or refinancing. Listed shares are indirect participation rights in corporations, projects and other entities; investors hold minority positions with limited ability to influence management. Unlisted shares often confer direct ownership, control, and operation of the corporate entity or project asset due to concentrated shareholder positions and closer ties to managers.
- Equity investors are interested in maximizing total return on equity – in the case of infrastructure, these objectives can be met through maximizing dividend yield since many projects lack a strong growth component. Other investor requirements (private equity) such as exit strategy are an important consideration.

Discussion (10 + 10 min)

- Consider that a certain developing country has 500 poorly populated cities lacking digital connectivity (no optic fibre reaching the cities, 3G mobile networks, and old, cooper infrastructure). The total population of these cities counts approx. 10% of the entire population of the country, and all of them are far from big cities and have no more than 30,000 inhabitants. 5% of the cities are in the middle of an area of preservation with strict environmental rules.
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  - Increase wireless broadband penetration from 10% to 95% in 3 years
  - Designed measures should focus on promoting adoption (demand-side) and investment (supply-side)
- Question for discussion:
  - ***How could European Commission delegation in the country contribute to the design and implementation of this national broadband policy?***
  - ***Detail the current EU initiatives and programs that could be supportive, as well as others that could be created.***

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Part 2 -Quiz

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