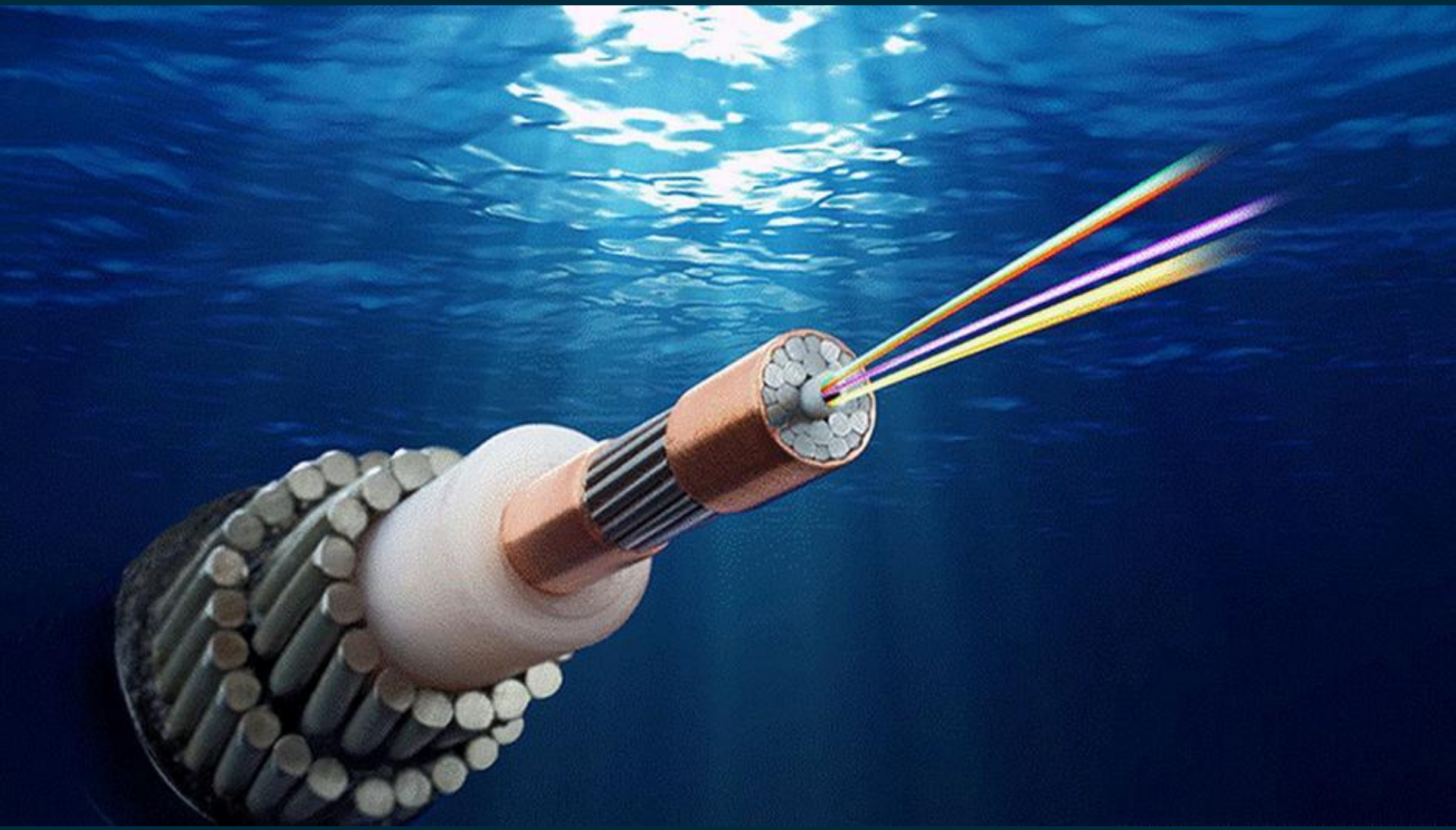
Chicago Network Operators Group

High Speed Subsea Optical Networks



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TELXIUS

Agenda

- History
- Network Architecture
- Testing and Measurement
- Maintenance and Marine Operation
- Upgrades and Increasing Capacity
- Current and Planned Capacity Outlook
- Q&A

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Agenda

History

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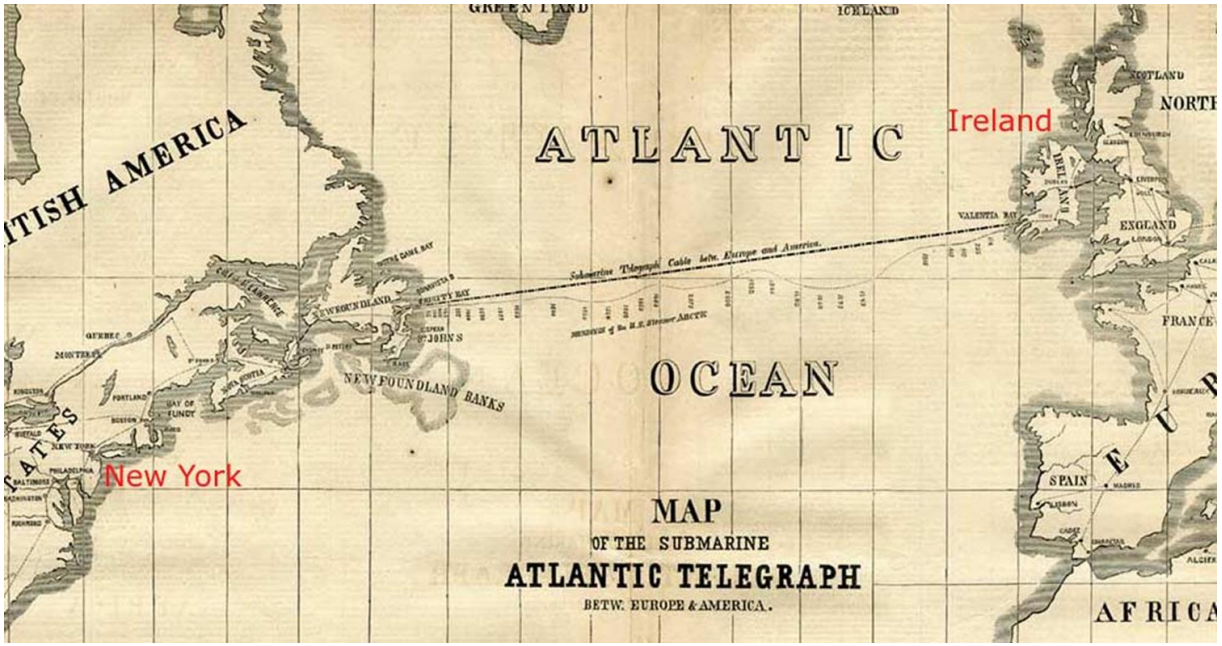
History

1850 –First Submarine Cable – English Channel

1858 –First Transatlantic Telegraph Cable - Valentia Island, Ireland and Newfoundland, Canada.

1866 - First Successful Transatlantic Telegraph Cable



"Atlantic Telegraph Cable Map"

Source – Bill Burns

History

1956 / 1978 - First Transatlantic Telephone *Coaxial* Cable - TAT 1 – Oban, Scotland and Newfoundland, Canada. Joint venture: British Post Office, the Canadian Overseas Telecommunications Corporation, and AT&T.
Capacity >> 36 Telephone Channels

1984 –First Submarine *Optical Fiber* Cable – English Channel

1988 - First Transatlantic Telephone *Optical Fiber* Cable – **TAT 8** – France, Britain, and the United States. Joint venture: AT&T, France Telecom, and British Telecom.
Capacity >> 40,000 Telephone Channels - 560Mb/s

1989 - First *privately financed* Transatlantic fiber optic Cable - **PTAT-1**
Capacity >> 1.26 Gb/s.

1996 – First Transatlantic fiber optic Cable which use Optical amplifiers - TAT-12/13 France, Britain, and the United States. Joint venture: AT&T, France Telecom, and British Telecom.
Capacity >> 10GB

Telxius in History

2000 –**SAm- 1** – South Americas 1 - United States, Puerto Rico, Brazil, Argentina, Chile, Peru, and Guatemala. (2007) Ecuador and Colombia.
Fully Owned by Telxius. Initial total design capacity of 480 Gbit/s, and with multiple upgrade capability using DWDM up to 19. 2 Tbit/s.

2014 Recovered – **UNISUR** - Argentina, Uruguay
Consortium owned/operated by Antel & Telxius
Capacity >> 2 Tbit/s

2015 **PCCS** – Pacific Caribbean Cable System- United States, Tortola, Puerto Rico, Aruba, Curacao, Colombia, Panama and Ecuador.
Consortium owned/operated by C&W Networks, Setar, Telconet, Telxius, United Telecommunication Services (UTS)
Capacity >> 80 Tbit/s

Telxius in History

2018 – **MAREA** - Highest-capacity subsea *cable* to cross the Atlantic. Connecting the United State (Virginia Beach) and Spain (Bilbao)
Owned by Microsoft, Facebook and Telxius.
Capacity >> Estimated 160 Tbits/s

2018 – **BRUSA** – High Speed Subsea Optical Cable - United States, Puerto Rico and Brazil.
Fully Owned by Telxius.
Capacity >> Estimated 120 Tbits/s

Agenda

Network Architecture

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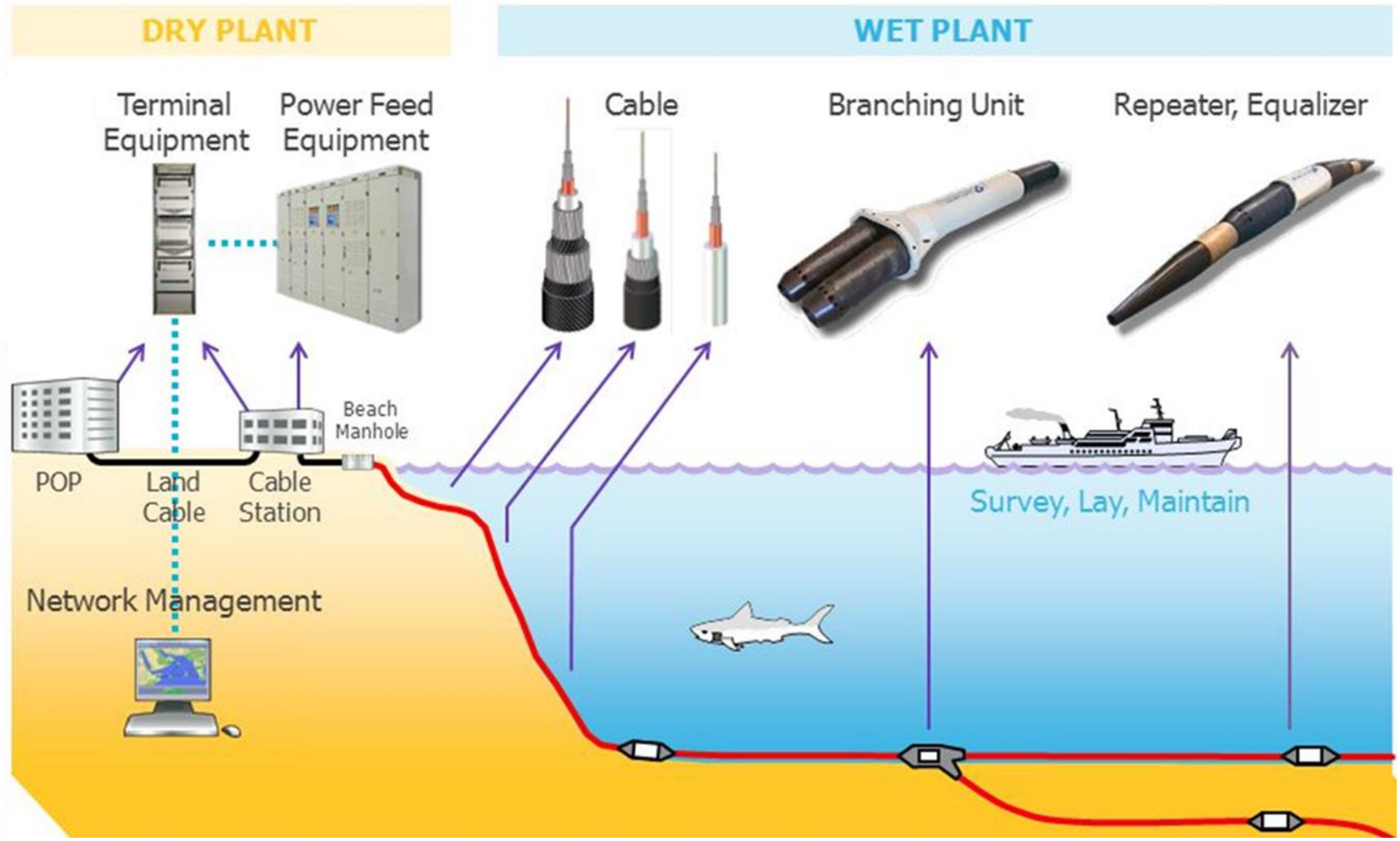
Network Architecture



Source - Alcatel Lucent

Network Architecture

Wet Plant components: **Cables**

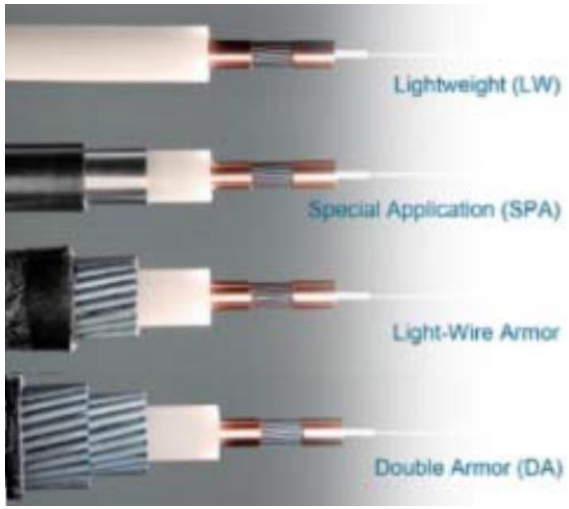
Coaxial Submarine Cable

Direct Buried FO Cable

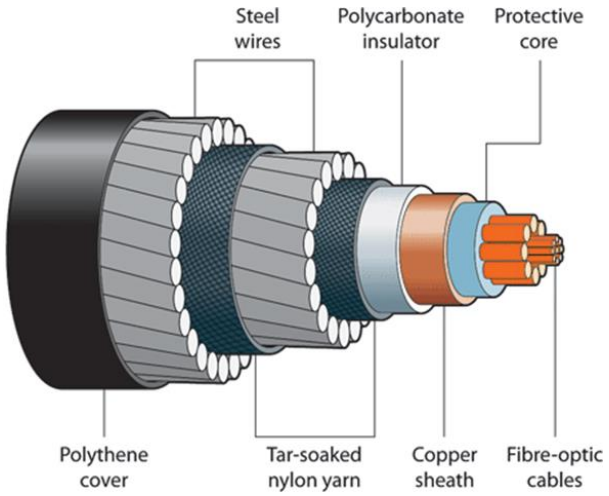
Submarine FO Cable

Network Architecture

Wet Plant components: **Submarine Fiber Optical Cables**



Undersea Cable	Typical Application
Light Weight (LW)	>2,000 Meter Depth
Special Application* (SPA)	900-2,000 Meter Depth
Light-Wire Armored (LWA)	Buried
Single Armored (SA)	400 to 900 Meter Depth
Double Armored (DA)	Beach Joint to 400 Meter Depth



Network Architecture and System Design

Wet Plant components:

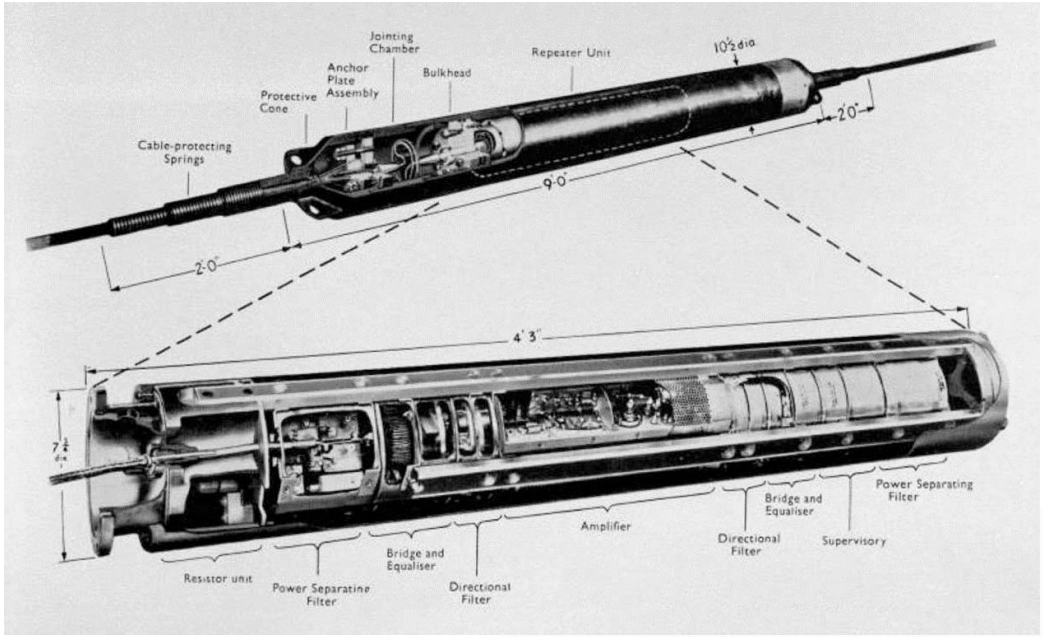
Submarine Fiber Optic used in main new cable system

Typical values at 1550nm

Fiber Specifications	Corning Vascade EX3000	Corning Vascade EX2000	Corning Vascade EX1000	Sunimoto Z-PLUS 130	Sunimoto Z-PLUs	Sunimoto Z
Attenuation (dB/km)	0.157	0.154	0.162	std: 0.162 ULL: 0.152	std: 0.168 LL: 0.160 ULL: 0.152	0.171
Effective Area (μm^2)	150	112	76	130	112	78
Dispersion (ps/nm.km)	+20.9	+20.2	+18.5	+20.5	+20.5	+18.5
Dispersion slope ($ps/nm^2.km$)	+0.06	+0.06	+0.06	+0.06	+0.06	+0.06
PMD ($ps/\sqrt{km}$)	≤0.05	≤0.05	≤0.05	≤0.02	≤0.02	≤0.02
ITU	G.654.D	G.654.B	G.654.C	G.654.D	G.654.D	G.654.C

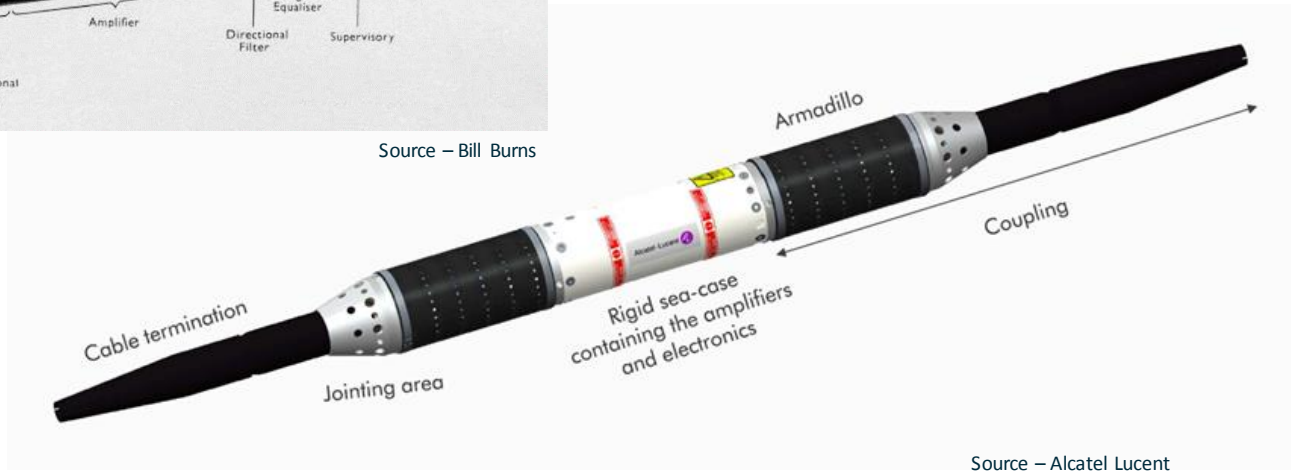
Network Architecture and System Design

Wet Plant components: **Repeaters and Equalizers**



Source – Bill Burns

Source – TESubcom

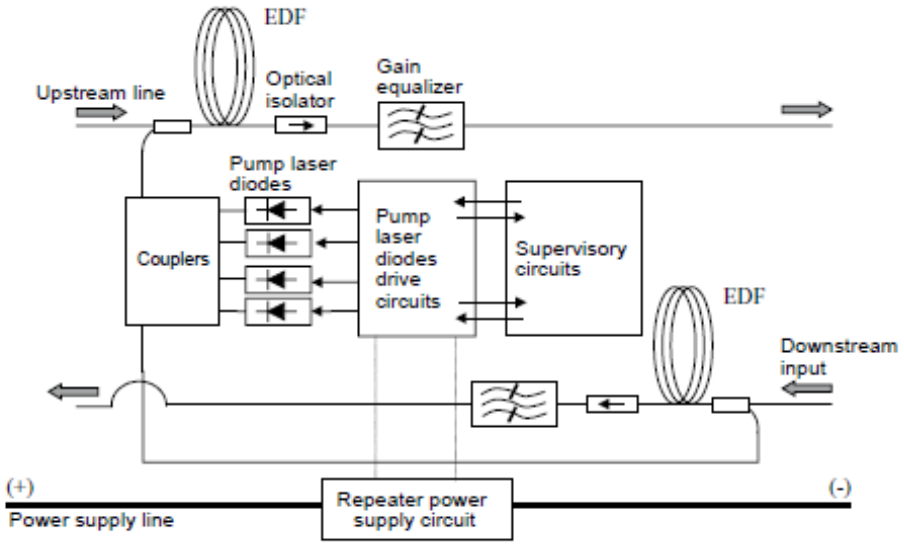


Source – Alcatel Lucent

Network Architecture

Wet Plant components: **Repeaters today**

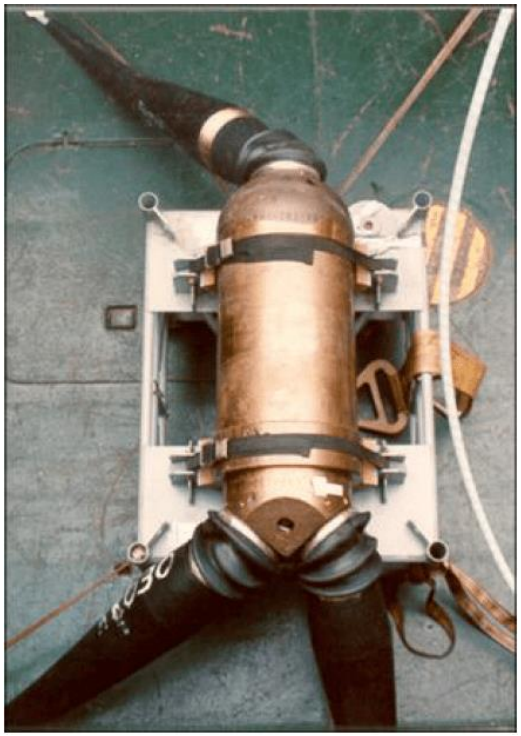
- Reliability over 25 years thanks to the redundant high quality 980nm pumps.
- Ultra large optical bandwidth to maximize the system capacity (EDF Optical Amplifiers)
- High resistance to water pressure and High performance sealing.
- Optical Monitoring Compatible with C-OTDR.

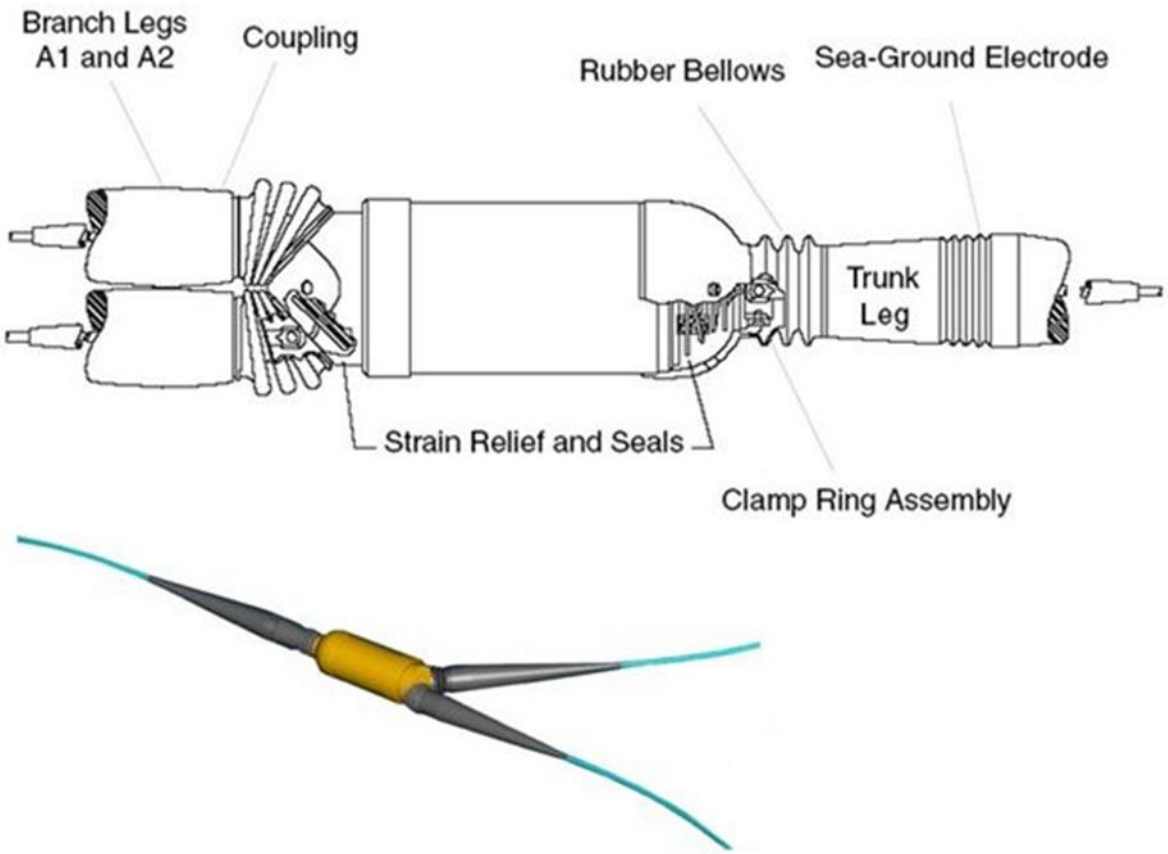


Characteristics	Typical Values
Amplifier Output Power	+15+/ 17/+20 dBm
Noise Figure	~4.5 dB
Bandwidth	30 – 40 nm
Repeater Gain	9 – 13 dB
Pumps	2, 3 or 4
Working Current	1 Ampere
Working Voltage	-15kV/+15kV
Voltage Drop 8FPs	~61 – 93 Volts
Max applicable depth	8,000 m
Material Housing	Beryllium–copper / Titanium

Network Architecture

Wet Plant components: **Branching Units**

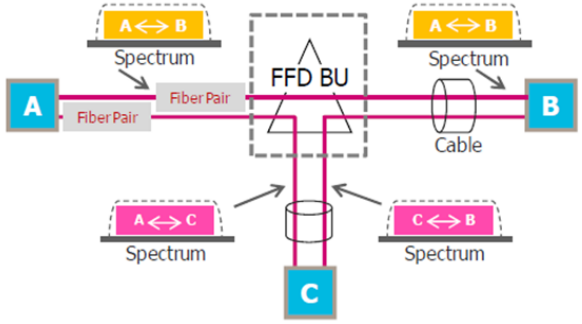




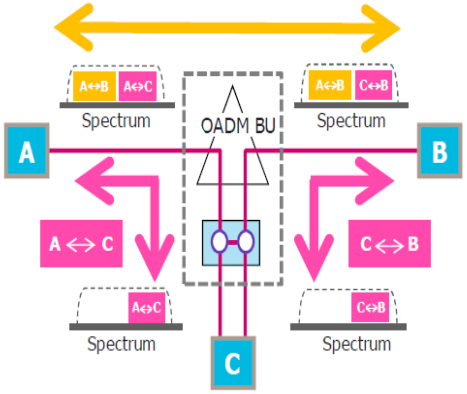
Source - SEACOM

Network Architecture

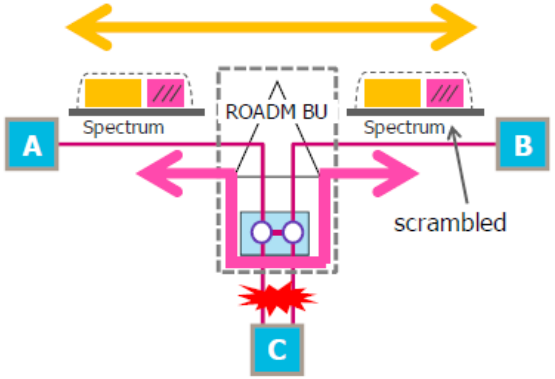
Wet Plant components: **Branching Units**



Full Fiber Drop Branching Unit (FFD-BU)



Optical Add/Drop Multiplexing Branching Unit (OADM-BU)



Reconfigurable Optical Add/Drop Multiplexing Branching Unit (ROADM-BU)

Source – Alcatel Lucent

Network Architecture

Wet Plant components:

Survey Vessel

Installation Ship

Sea Plow for Cable Burial Operation

Maintenance Vessel

Source - David Ross Group

Network Architecture

Dry Plant components:

PFE (Power Feed Equipment),

Terminal Equipment TE

DWM

Solutions Options offered today in the market

- Turnkey System
- Open Cable

Agenda

Testing and Measurement

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Testing and Measurement

Prequalification /System Assembly Test

- Insulation of the power feeding line, voltage drop during
- power feeding.
- Trace measurement of optical fibers (C-OTDR).
- Wavelength dispersion of optical fibers.
- Gain flatness
- Optical spectrum and optical SNR (Signal to Noise Ratio)

System Construction and Commissioning Test

- Insulation resistance of submarine plant, voltage drop.
- Optical SNR and Q-value (error rate).
- Monitoring network test (alarm, monitor, etc.).
- Long-term stability (Q-value, alarm).

Agenda

Maintenance and Marine Operation

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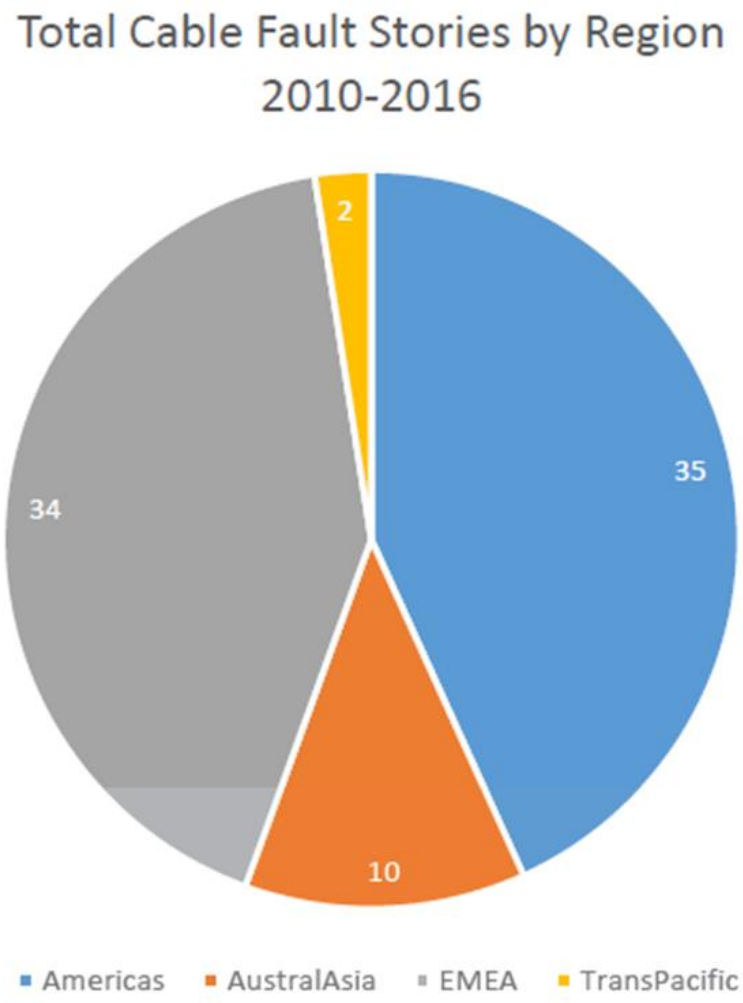
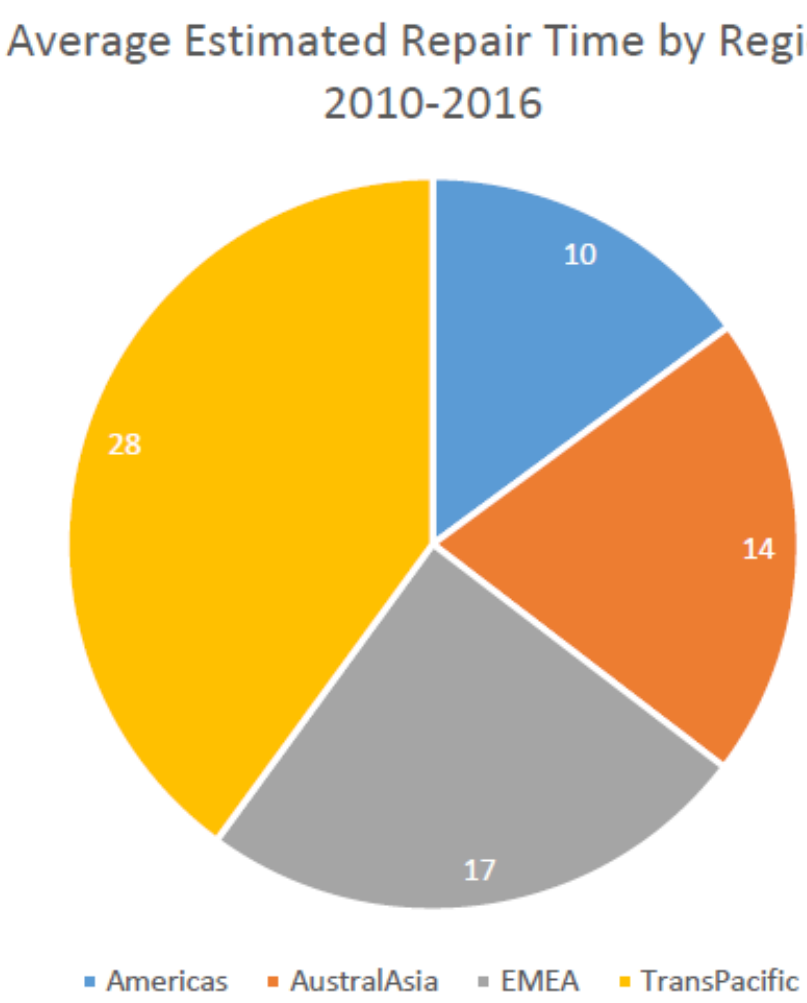
Maintenance and Marine Operation





Source - SUBTEL

Maintenance and Marine Operation

- Vessel Monitoring System (VMS)
- Air and Sea Patrols
- Terrestrial Patrols
- National Legislation

- Cable Maintenance Agreements

C.S. Wave Sentinel
Based at Curacao, Netherlands Antilles, operated by Global Marine

Source - ACMA

Maintenance and Marine Operation

Traditional Club Agreements

NAZ –North America Zone
ACMA –Atlantic Cable Maintenance Agreement
MECMA –Mediterranean Cable Maintenance Agreement
SEAIOCMA –South East Asia and Indian Ocean Cable Maintenance Agreement
Yokohama Zone

Source - SUBTEL

Maintenance and Marine Operation

Private Club Agreements

APMA –Atlantic Private Maintenance Agreement, including MED –ASN and SubCom
APMMSA –Asia Pacific Private Maintenance Agreement -ASN and SubCom
NPMMSA –Northern Pacific Zone –SubCom
South Pacific Zone -ASN
Red Σεα, Persian Gulf, Indian Arabian Sea –E Marine
South African Agreement -FTM

Source - SUBTEL

Agenda

Upgrades and Increasing Capacity

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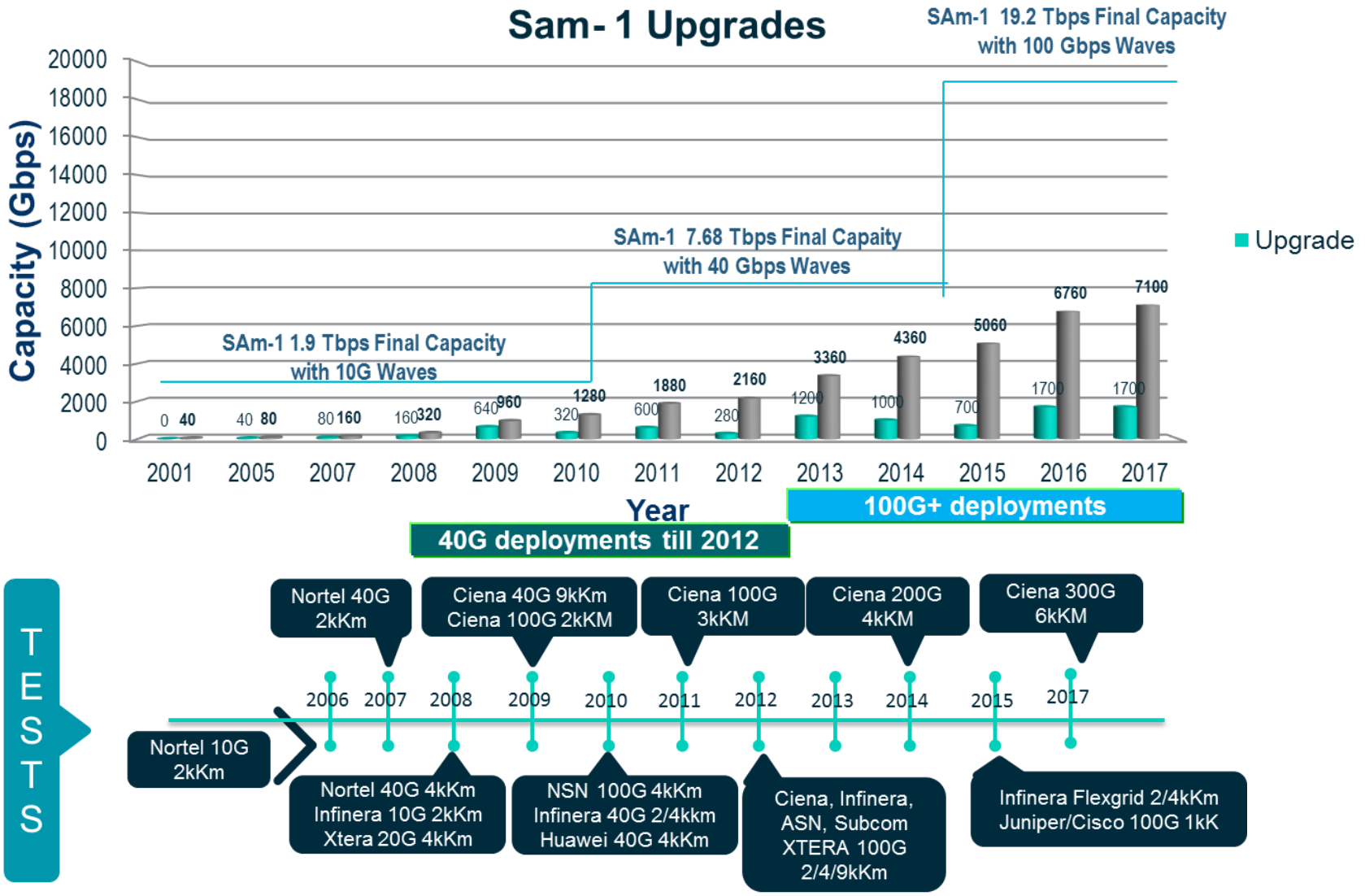
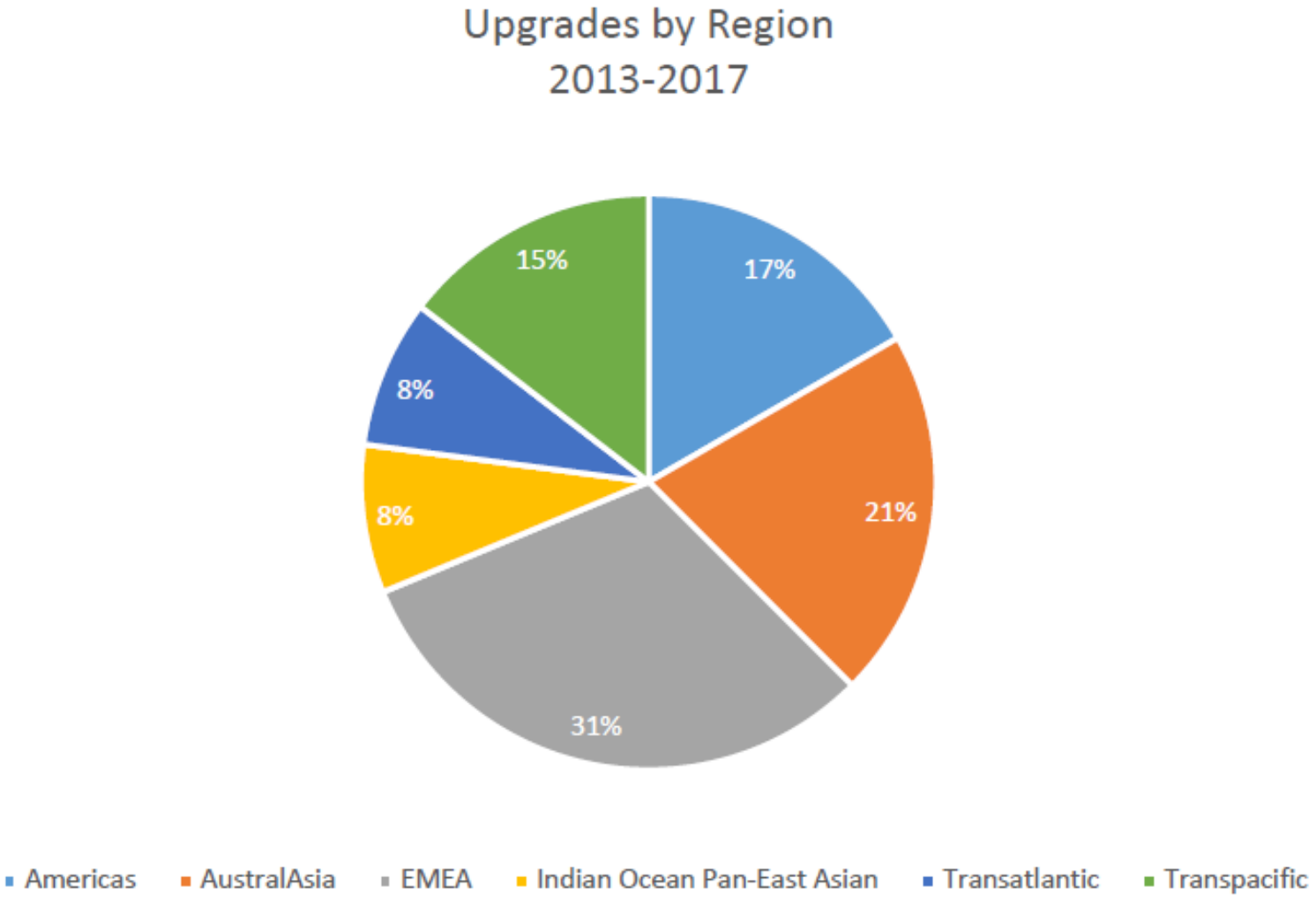
Upgrades and Increasing Capacity

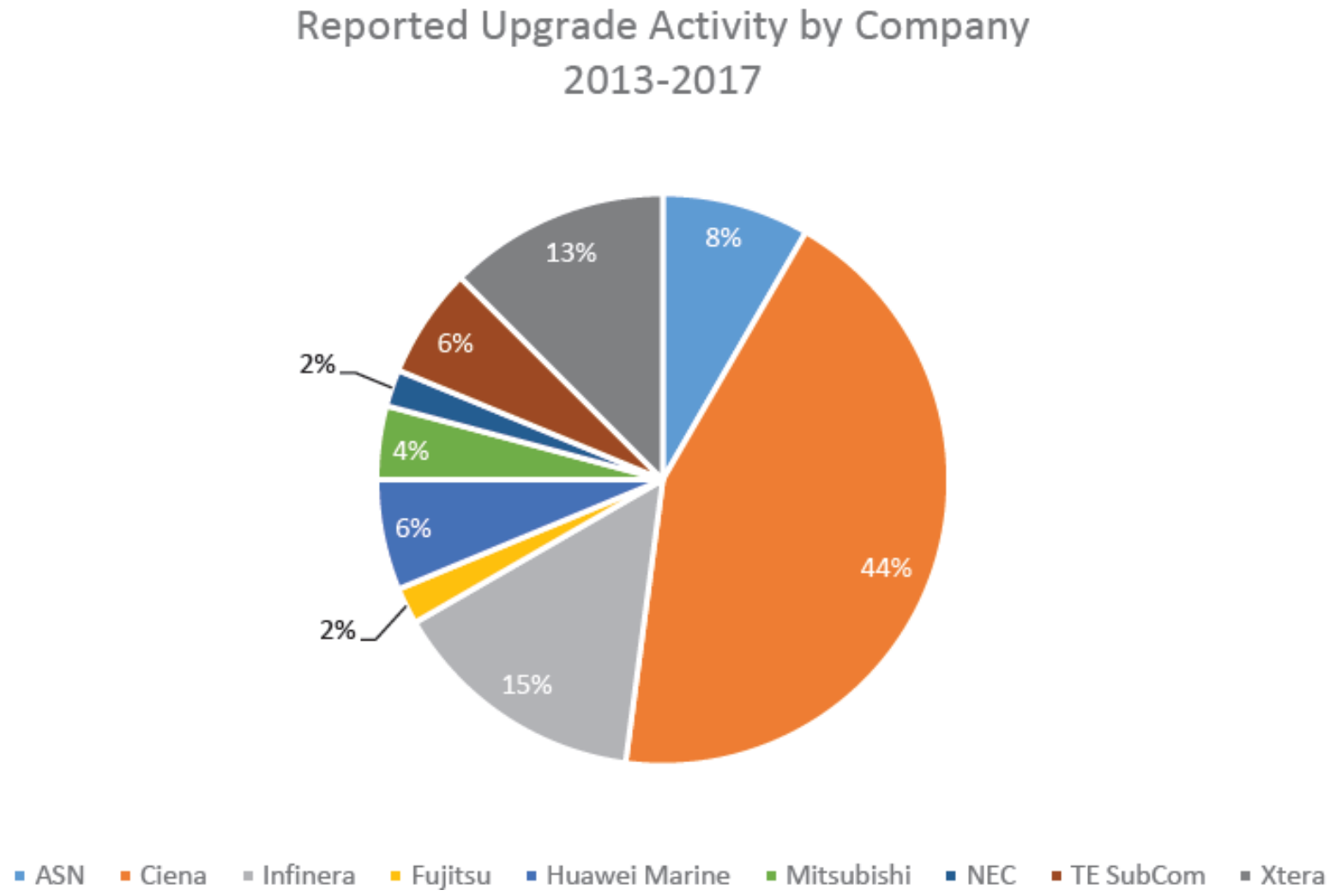


Upgrades and Increasing Capacity



Source - SUBTEL

Upgrades and Increasing Capacity



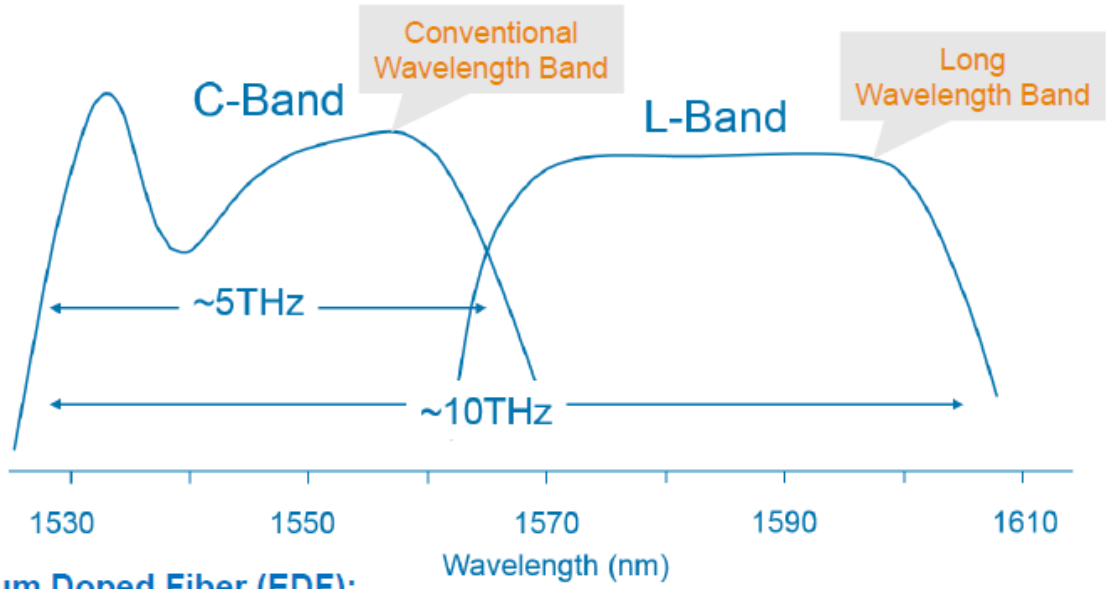
Source - SUBTEL

Upgrades and Increasing Capacity

Increasing Capacity

Doubling Fiber Pair Capacity (C+L) Vs More Fiber Pairs

More Bandwidth per Fiber Pair



Erbium Doped Fiber (EDF):

- Natural amplification in the C-band (1525 – 1565 nm)
- Amplification in the L-band (1565 – 1610 nm) if no light in C-band

Source - TESubcom

Agenda

Current and Planned Capacity Outlook

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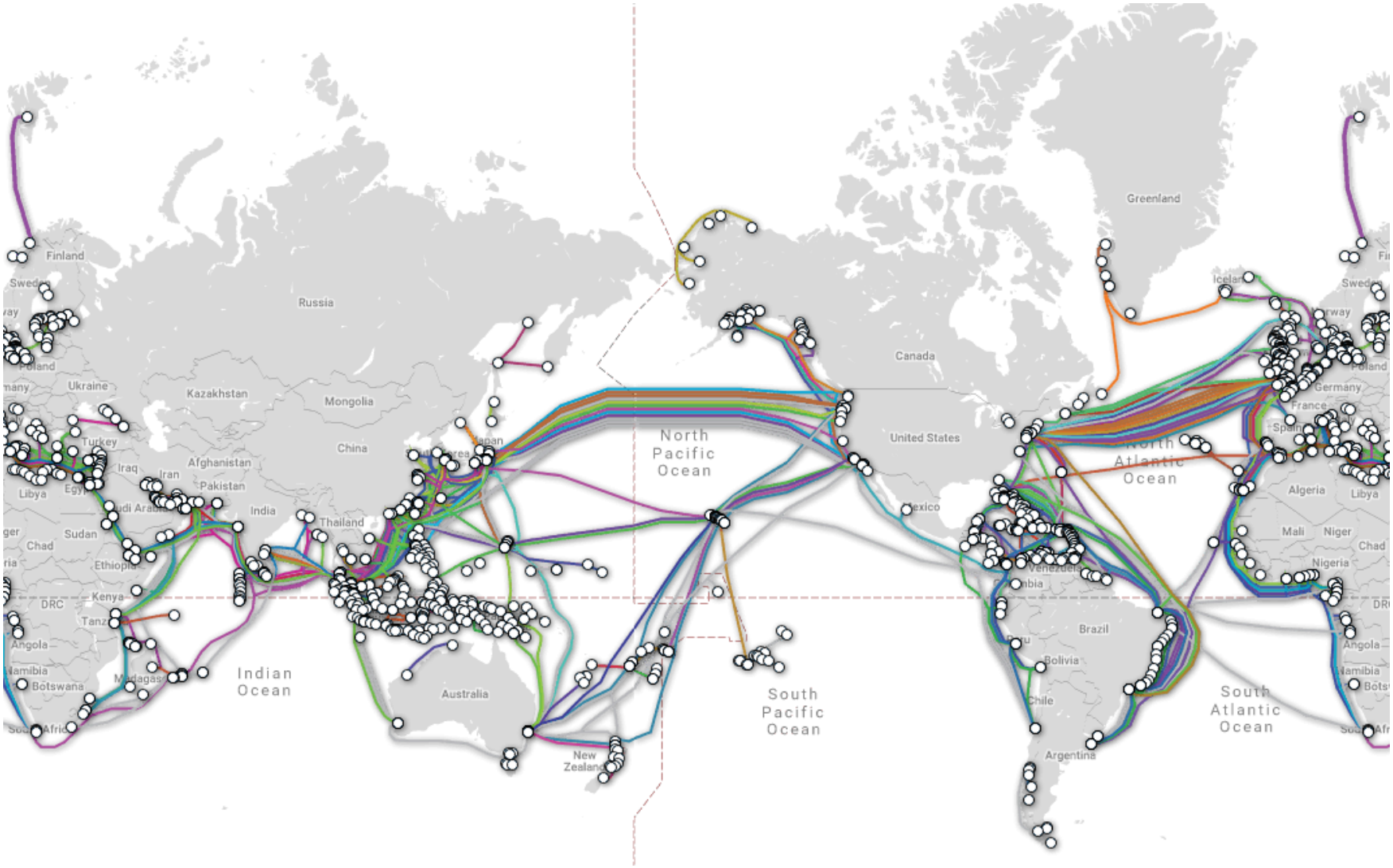
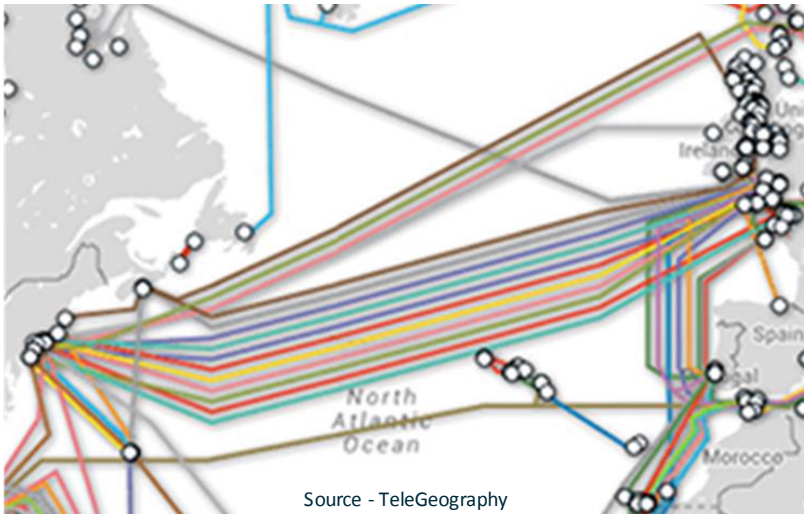
Current and Planned Capacity Outlook



Source - TeleGeography

Current and Planned Capacity Outlook

Transatlantic Region



Source - TeleGeography

Current Systems 2000 - 2017

RFS	System	Length	Capacity
2000	Atlantic Crossing 2	6,185	5.2 Tbps
2000	Atlantis-2	13,100	160 Gbps
2001	FLAG Atlantic 1 North/ South	12,820	24 Tbps
2001	Hibernia Atlantic	12,111	25 Tbps
2001	TAT-14	15,453	9.38 Tbps
2001	TGN Transatlantic	12,670	50 Tbps
2003	Apollo	12,700	64 Tbps
2015	Hibernia Express	4,600	53 Tbps
2016	America Europe Connect	5,536	78 Tbps
2017	Marea	6,600	160 Tbps

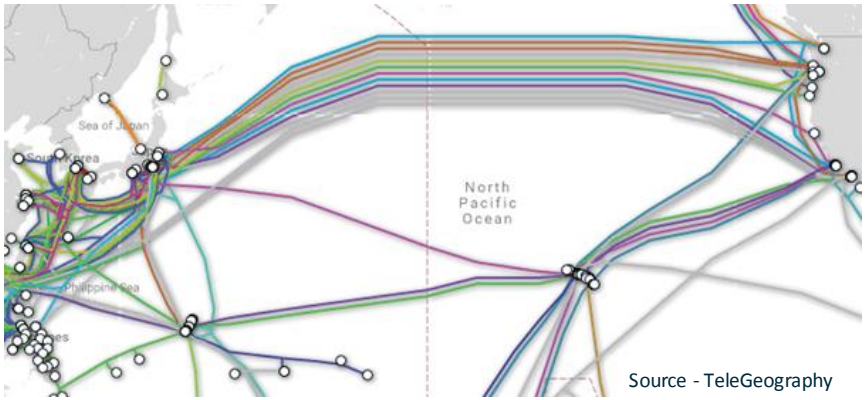
Planned Systems

RFS	System	Length	Capacity
2018	SACS	6,200	40 Tbps
2018	SAIL	5,900	32 Tbps
2019	EllaLink	10,119	72 Tbps
2019	SAEx	17,230	48 Tbps

Source - SUBTEL

Current and Planned Capacity Outlook

Transpacific Region



Source - TeleGeography

Current Systems 2000 - 2016

RFS	System Name	Length	Capacity
2000	Southern Cross Cable Network	30,000	14 Tbps
2000	Pacific Crossing 1	20,910	8.4 Tbps
2001	Australia-Japan Cable	12,224	25.6 Tbps
2001	China-US	30,444	5 Tbps
2001	Japan-US	21,880	6.4 Tbps
2002	TGN Transpacific	21,424	5.12 Tbps
2008	Trans-Pacific Express	16,163	5.12 Tbps
2009	Asia-America Gateway	20,547	2.88 Tbps
2010	Unity	9,486	7.68 Tbps
2016	Faster	9,000	60 Tbps
2017	SEA-US	15,000	20 Tbps

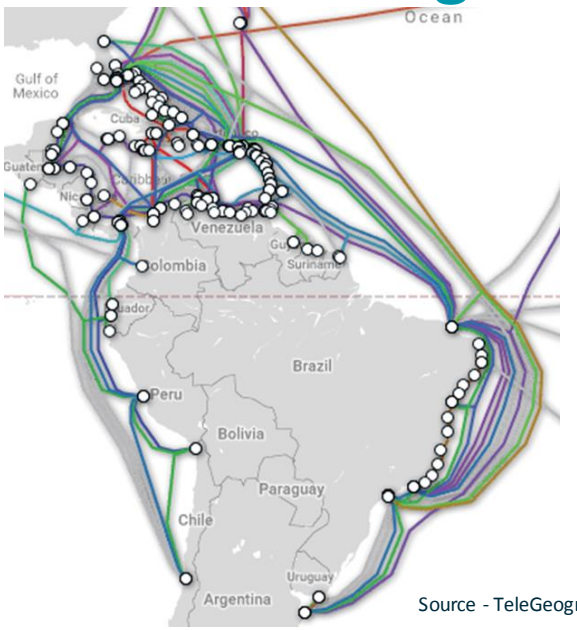
Planned Systems

RFS	System Name	Length	Capacity
2018	Hawaiki	7,000	30 Tbps
2018	NCP	13,618	80 Tbps
2018	PLCN	12,800	120 Tbps
2019	SAPL	17,600	30 Tbps
2019	Southern Cross NEXT	12,500	48 Tbps

Source - SUBTEL

Current and Planned Capacity Outlook

Americas Region



Source - TeleGeography

Planned Systems

RFS	System Name	Length	Capacity
2018	ARBR	500	24 Tbps
2018	Austral	1,800	24 Tbps
2018	BRUSA	11,000	120 Tbps
2018	Greenland Connect North	300	4.8 Tbps
2018	Guantánamo Bay 2	1,200	20 Tbps

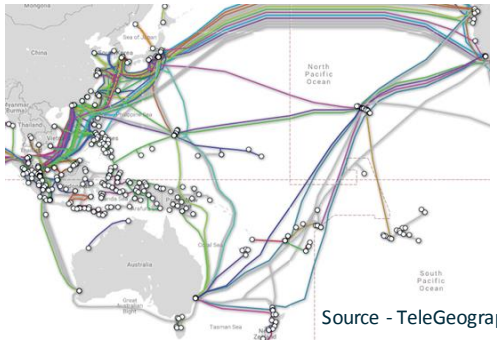
Current Systems 2010 - 2017

RFS	System Name	Length	Capacity
2010	Antel	250	3.84 Tbps
2010	Suriname-Guyana Submarine Cable System	1,249	3.6 Tbps
2011	East-West	1,700	1.6 Tbps
2013	ALBA-1	1,600	5.12 Tbps
2014	America Movil Submarine Cable System-1	17,800	50 Tbps
2015	Pacific Caribbean Cable System	6,000	48 Tbps
2016	Guantánamo Bay Cable	1,500	20 Tbps
2017	Junior	250	60 Tbps
2017	Monet	10,556	60 Tbps
2017	Quintillion Subsea	1,200	30 Tbps
2017	Seabras-1	10,750	30 Tbps
2017	Tannat	2,000	90 Tbps

Source - SUBTEL

Current and Planned Capacity Outlook

AustralAsia Region



Source - TeleGeography

Planned Systems

RFS	System Name	Length	Capacity
2018	ASC	4,600	40 Tbps
2018	Moana	9,700	20 Tbps
2018	Mythic	1,600	20 Tbps
2018	Samoa-Fiji	1,300	20 Tbps
2018	SEAX-1	250	24 Tbps
2018	Trident	4,600	28 Tbps
2018	Hawaiki	7,000	42 Tbps
2019	Best Cable System	5,092	24 Tbps
2019	Indigo Central	4,850	18 Tbps
2019	Indigo West	9,000	18 Tbps

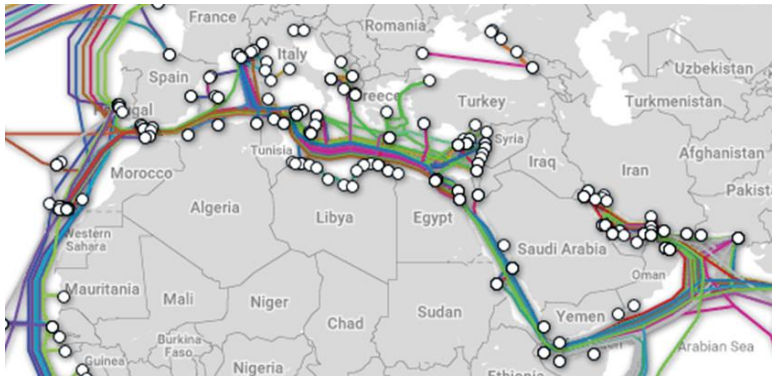
Current Systems 2013 - 2017

RFS	System Name	Length	Capacity
2013	Asia Submarine-cable Express	7,200	15.36 Tbps
2013	GOKI	4,200	80 Gbps
2013	South-East Asia Japan Cable	8,986	28 Tbps
2013	Boracay-Palawan	332	4.8 Tbps
2013	Taiwan Strait Express	270	6.4 Tbps
2014	Interchange I	1,259	320 Gbps
2015	Broadband Linking the American Samoa Territory	250	24 Tbps
2015	Sulawesi-Maluku-Papua Cable System	2,000	40 Gbps
2015	Far East	1,844	1.6 Tbps
2017	Asia Pacific Gateway	10,400	38.4 Tbps
2017	ATISA	280	20 Tbps
2017	MCT	1,425	30 Tbps
2017	Palau-Guam	250	24 Tbps
2017	SKR1M	3,500	4 Tbps
2017	SOCC	827	8 Tbps
2017	Tasman Global Access	2,300	20 Tbps
2017	Tui-Samoa	1,470	1,470

Source - SUBTEL

Current and Planned Capacity Outlook

EMEA Region



Source - TeleGeography

Planned Systems

RFS	System Name	Length	Capacity
2018	DARE	5,500	60 Tbps
2018	IFC-1	565	120 Tbps
2018	Liquid Sea	10,000	30 Tbps
2018	Orval	560	20 Tbps
2018	SRG-1	1,000	24 Tbps

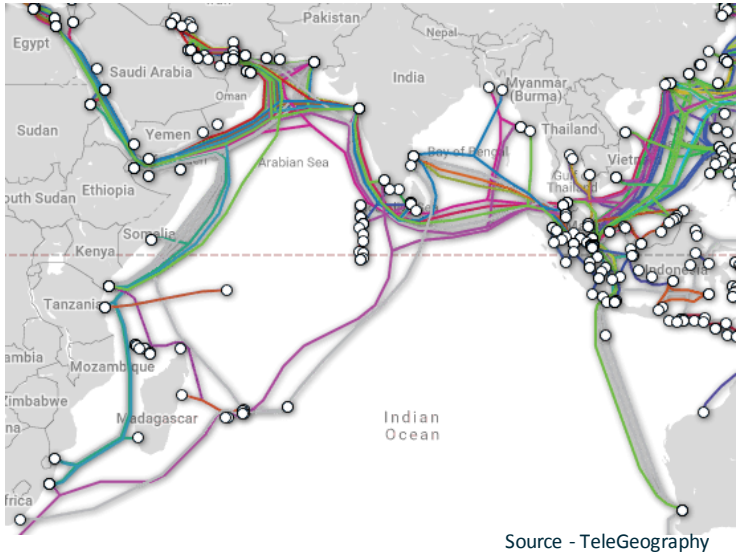
Current Systems 2012 - 2017

RFS	System Name	Length	Capacity
2012	ACE	17,000	12.8 Tbps
2012	Alasia	350	25.6 Tbps
2012	Silphium	426	1.2 Tbps
2012	Solas	140	5 Gbps
2012	WACS	14,350	14.5 Tbps
2014	MENA	8,800	57.6 Tbps
2014	Flores-Corvo	685	0.96 Tbps
2014	Didon	173	18 Tbps
2015	NCSCS	1,100	12.8 Tbps
2016	C-Lion1	1,172	144 Tbps
2017	SEA-ME-WE 5	20,000	24 Tbps
2017	Ceiba-2	290	8 Tbps
2017	Eastern Light	250	20 Tbps

Source - SUBTEL

Current and Planned Capacity Outlook

Indian Ocean
Pan-East Asian Region



Source - TeleGeography

Current Systems 2006 - 2017

RFS	System Name	Length	Capacity
2006	Falcon	12,181	2.56 Tbps
2007	Bharat-Lanka	338	0.96 Tbps
2009	LION	1,091	1.28 Tbps
2009	Seacom	13,601	4.2 Tbps
2009	TEAMS	4,500	1.28 Tbps
2009	TGN Eurasia	9,240	1.28 Tbps
2012	LION-2	3,000	1.28 Tbps
2014	BBG	8,040	55 Tbps
2017	SEA-ME-WE 5	20,000	24 Tbps
2017	AAE-1	25,000	40 Tbps

Planned Systems

RFS	System Name	Length	Capacity
2018	Australia West Express	10,100	20 Tbps
2019	Indian Ocean Exchange	8,850	26 Tbps

Source - SUBTEL

Agenda

Q&A

Tabata Materan

Enabling Communication

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