Submarine Cable Technology and Trends

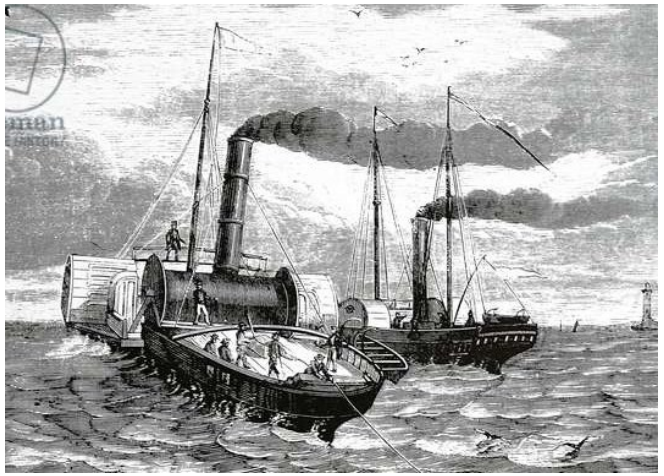
Roeland Nuijts, PhD

14th SIG-NGN Meeting, April 8th-9th 2024, Catania, Italy

Introduction to Subsea

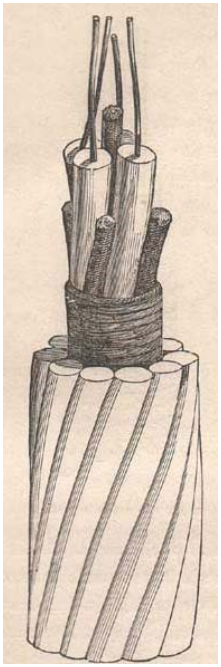
Submarine Cable Systems - the beginning

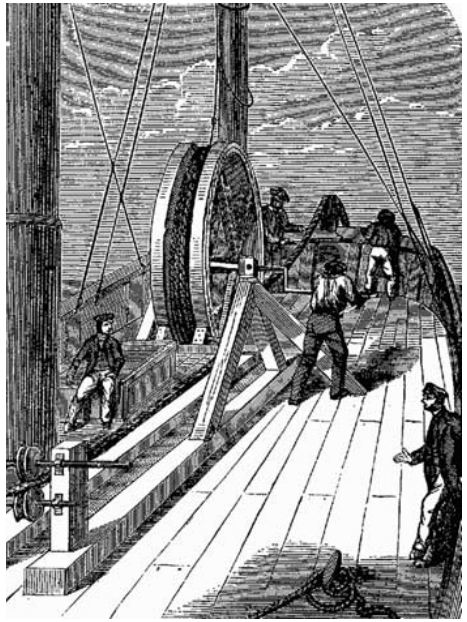
The Goliath and the Widgeon laying the first submarine cable between Dover and Calais



- **First submarine cable UK-France deployed in 1850**
- **Useful life 11 minutes**

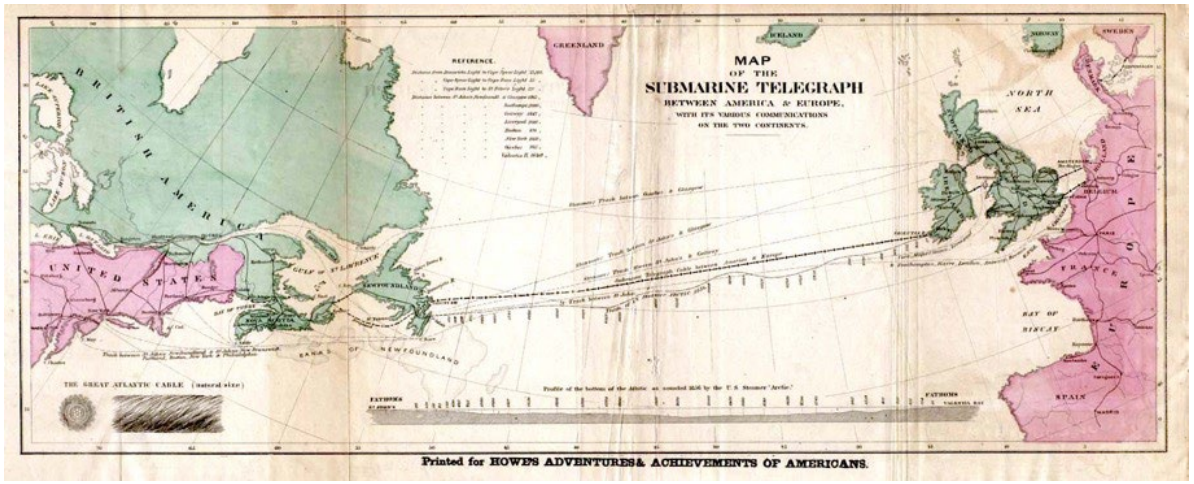
- **Second UK-France deployed in 1851**
  - First commercially successful undersea cable
  - 25 miles total length, weighing 7 tons / mile



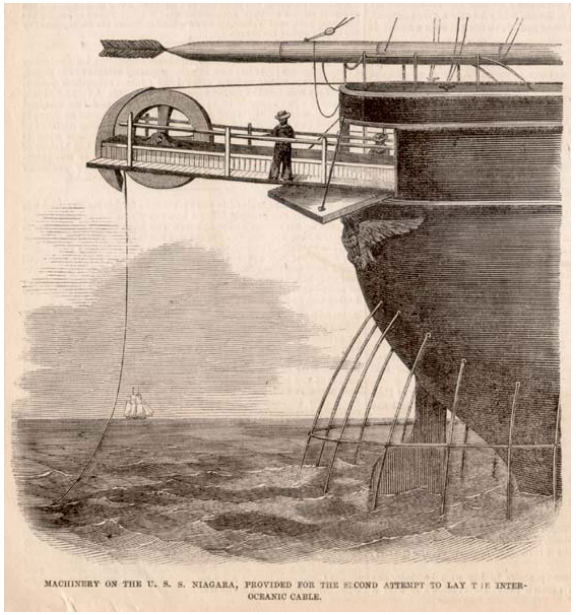


Introduction to Subsea

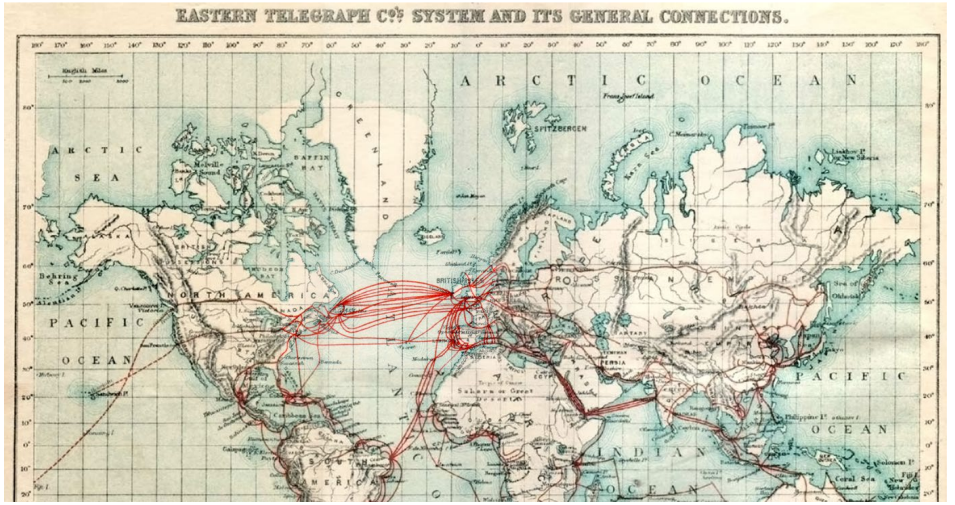
Submarine Cable Systems - the beginning



- **First transatlantic cable in 1858**
  - First message August 1858 sent by Queen Victoria to US President James Buchanan
    - 98 words and took 17 hours to transmit
  - Declared the 8th wonder of the world
  - Lasted 3 weeks but proved the concept


MACHINERY ON THE U. S. S. NIAGARA, PROVIDED FOR THE SECOND ATTEMPT TO LAY THE INTER-OCEANIC CABLE.

- **By 1901 cables spanned the globe**

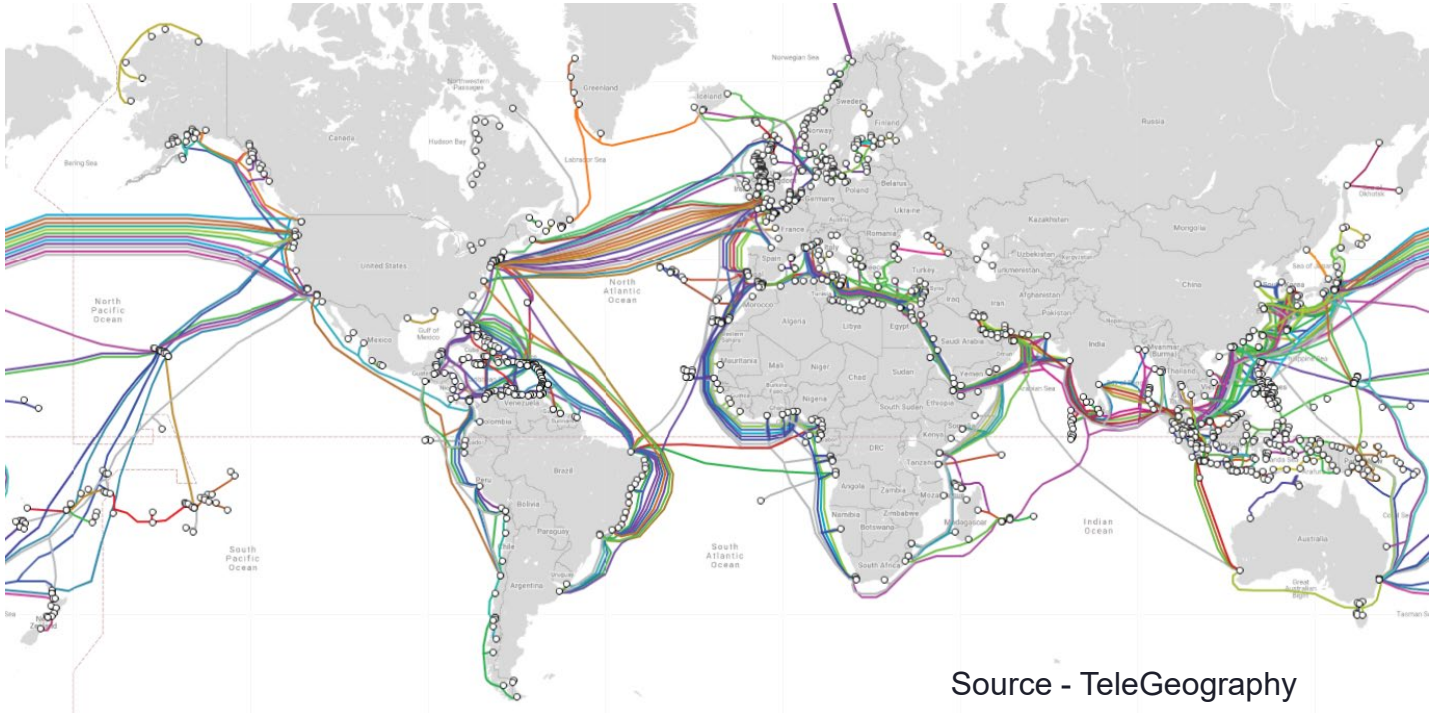


Introduction to Subsea

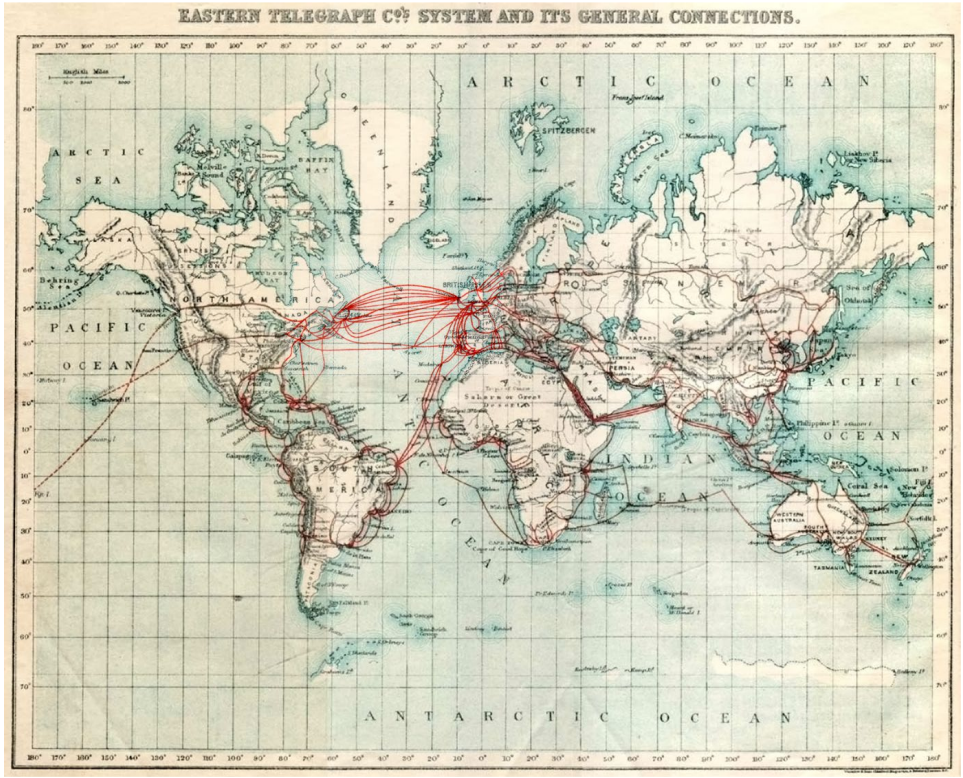
Submarine Cable Systems - today

Submarine cables deployed globally

- **https://www.submarinecablemap.com/**
- **>450 in-service cables**
- **1.4 million kms of cable**
- **1,400 landing points**



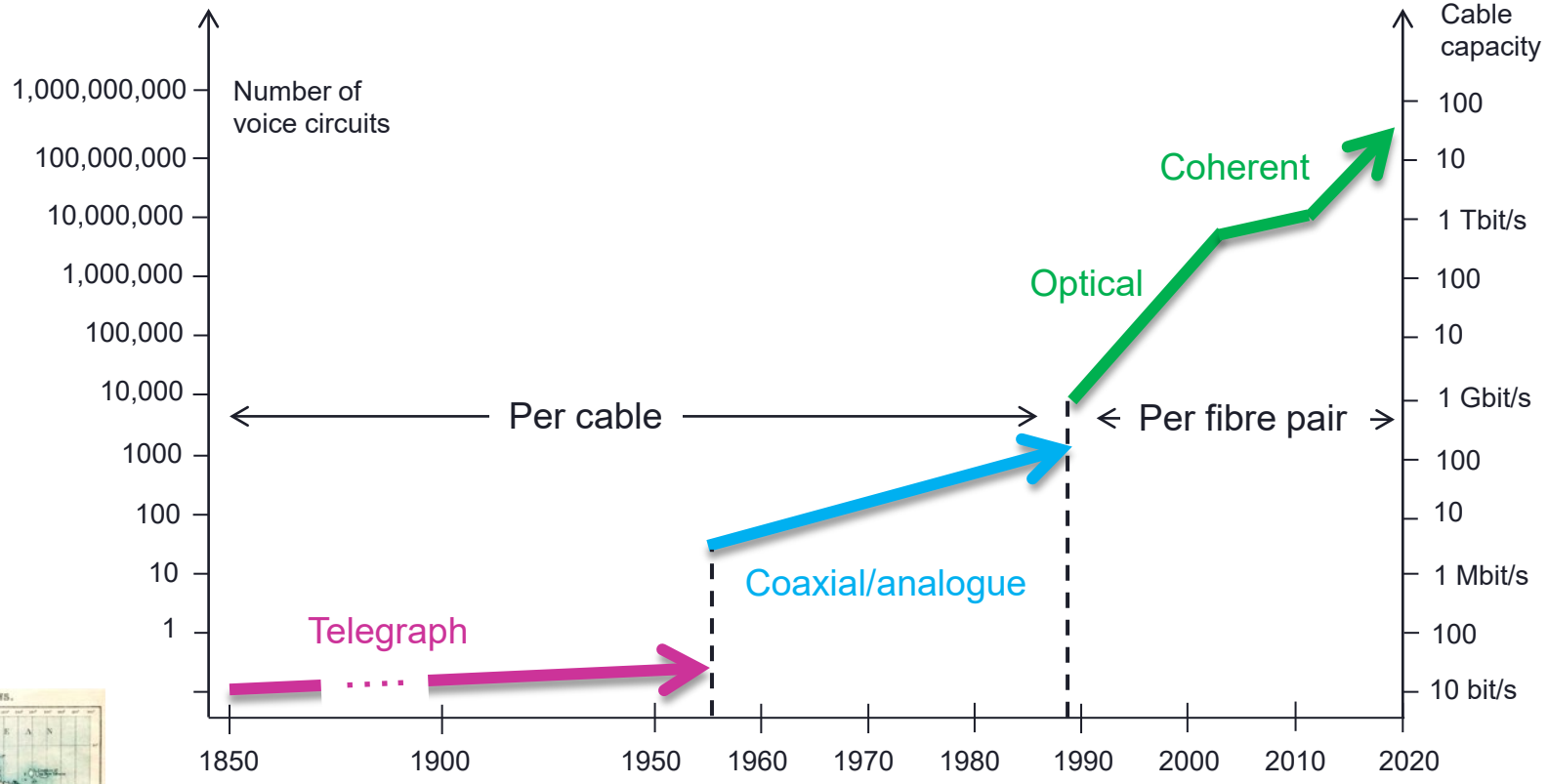
Source - TeleGeography



- **Carry >99% international traffic**
- **High reliability, 25-year lifetime**
- **Deployed to 9000m water depth**
- **Up to 20,000kms in length**

Introduction to Subsea

Submarine Cable History - Three generations

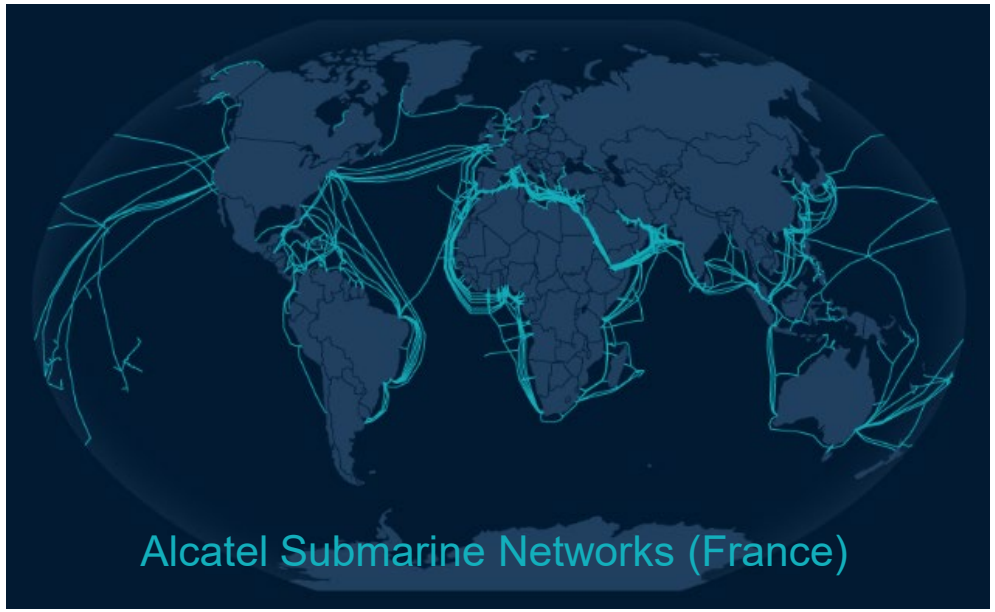


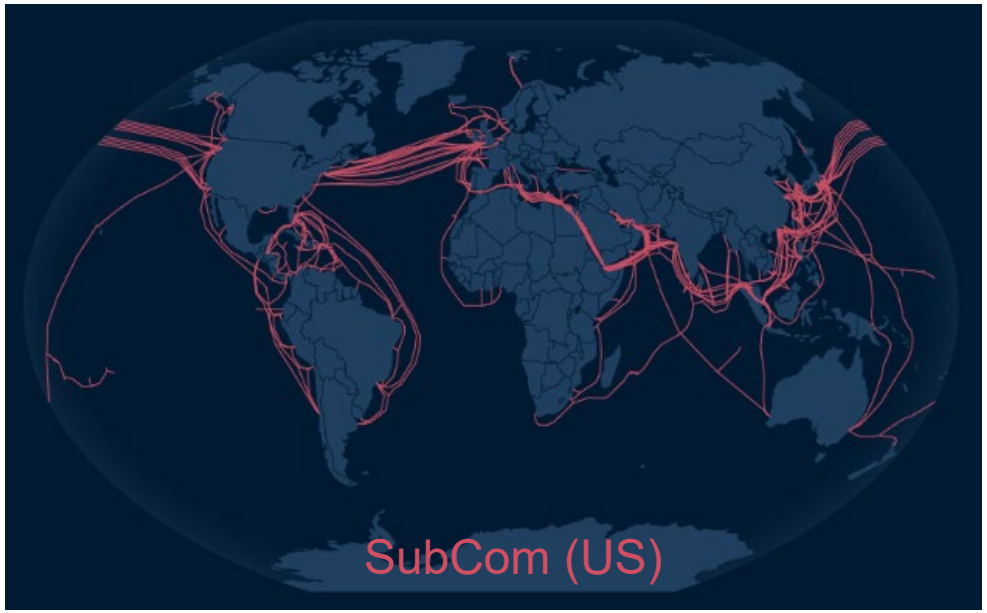
- By 1910 400,000kms cable laid
- Development of cable industries in UK, France, Germany & Japan
- Marine capabilities improving

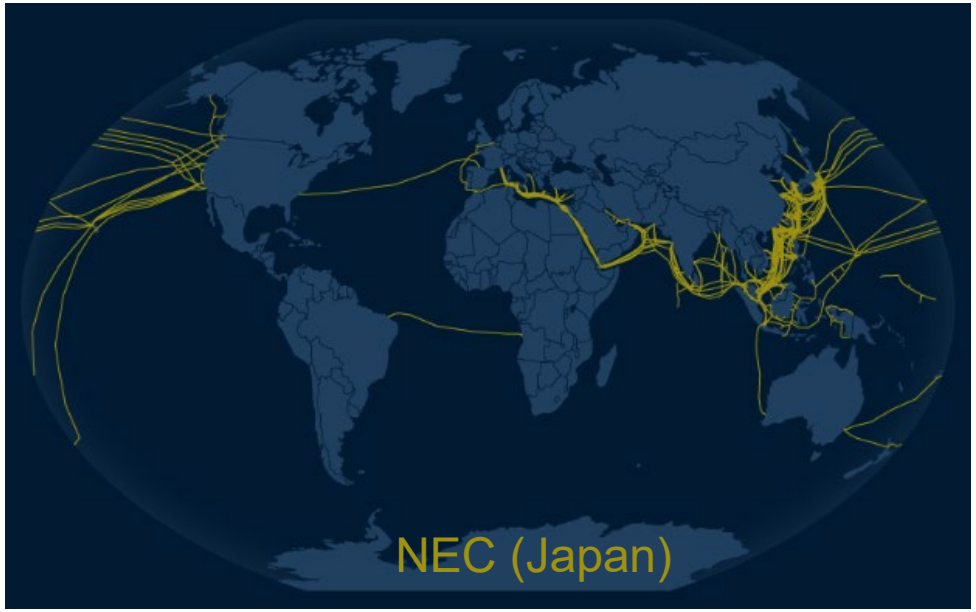
- After WWII co-axial technology proven
- Development of undersea repeaters and new cable
- Telegraph to telephony

Introduction to Subsea

Wet plant suppliers – the big three

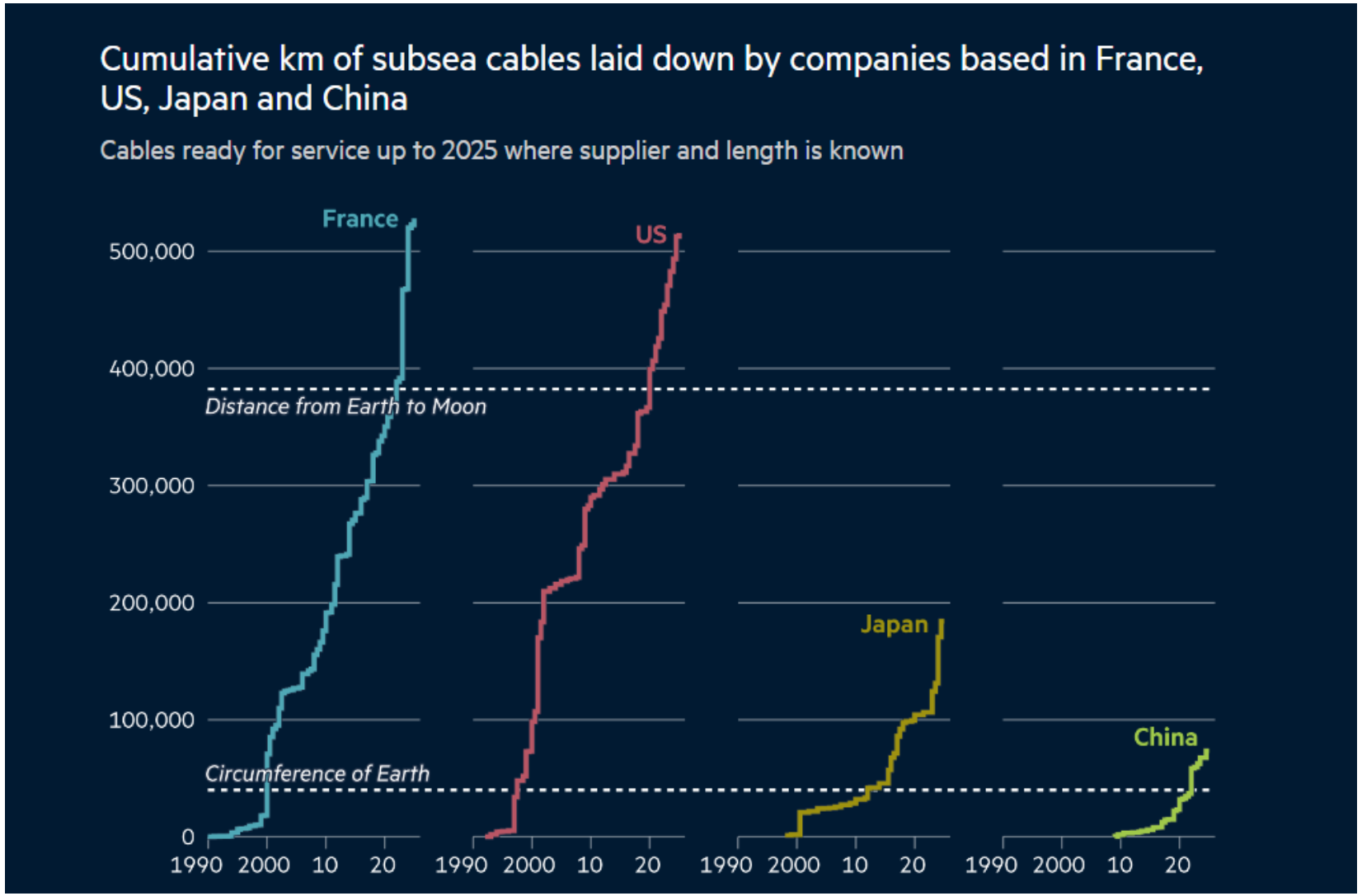






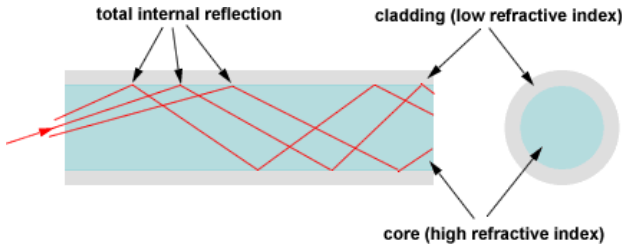
Introduction to Subsea

Wet plant suppliers - the big three +



Introduction to Subsea

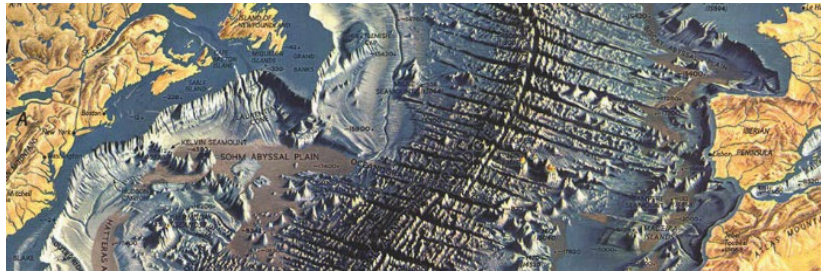
Submarine Cable Systems - FAQs



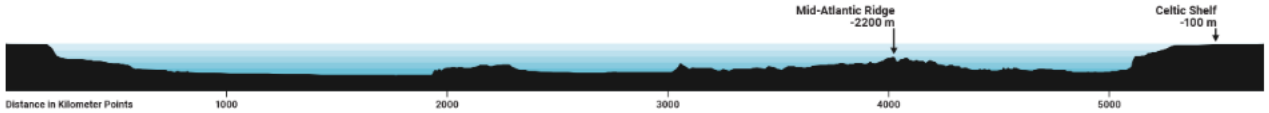
- **How do cables work?**
  - Submarine cables use fibre-optic technology - lasers transmit pulses of light down glass fibre which carries the data to receivers at far end of cable by total internal reflection.
- **How big are the cables?**
  - In deep water a cable is as wide as a garden hose. The filaments that carry light signals are extremely thin - roughly the diameter of a human hair.
  - These fibers are sheathed in a few layers of insulation and protection. Cables laid nearer to shore use extra layers of armoring for enhanced protection.
- **Do the cables lie on the bottom of the ocean floor?**
  - Cables are armoured and buried under the seabed for protection in shallow water, in deep sea (>1000m) they are laid directly on the ocean floor.
- **How are cables laid?**
  - Cables are laid by specialist marine vessels capable of deploying and recovering to 9000m.
- **What about satellites?**
  - Satellites are used to reach areas not yet connected with fibre. They are also useful for distributing content from one source to multiple locations.
  - Otherwise fibre optic cables carry far more data, far quicker and are far lower cost than satellites.

Introduction to Subsea

Submarine Cable Systems - FAQs



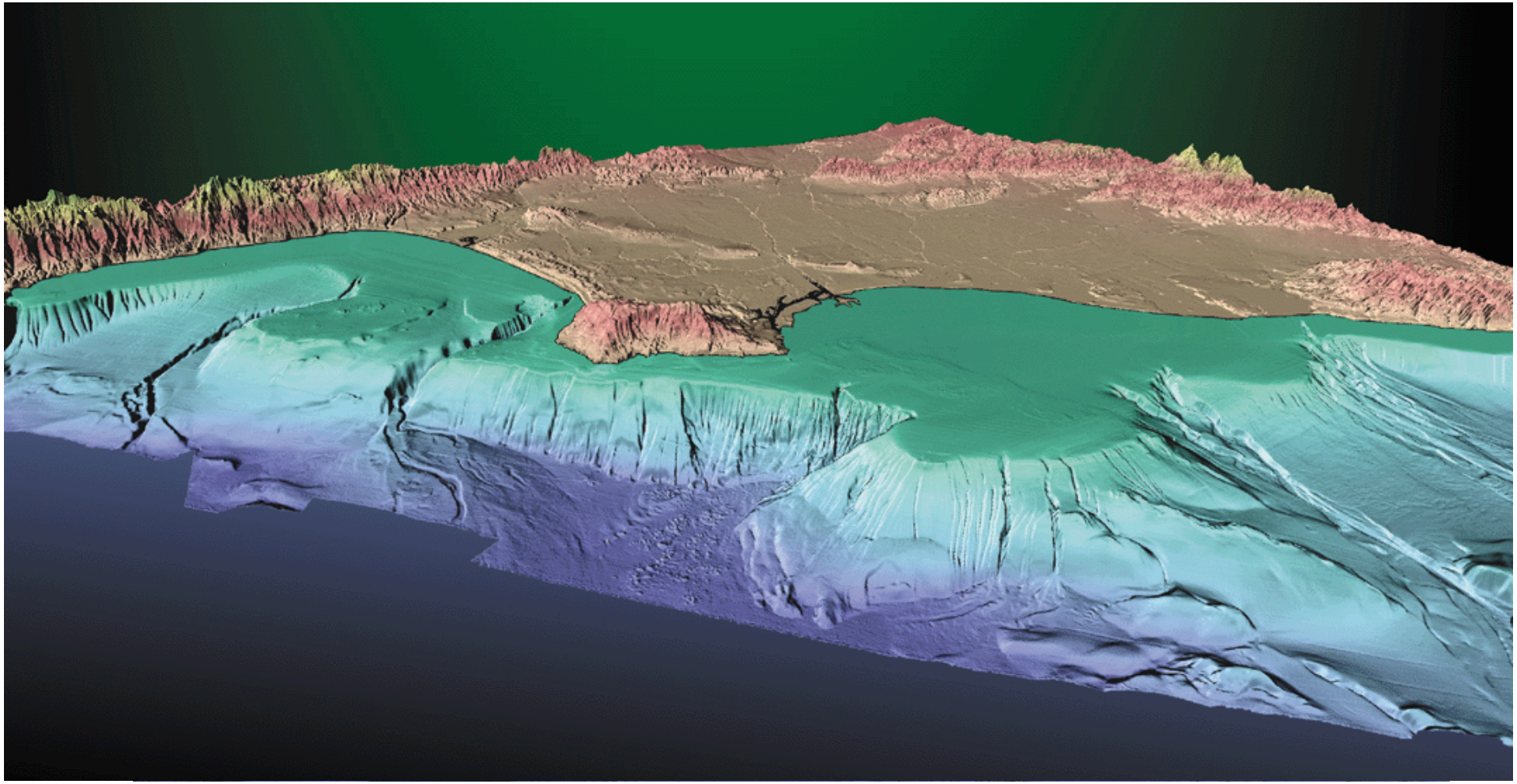
- **Where are the cables laid?**
  - Cable route engineering is critical
  - Considerable care is taken to ensure cables follow the safest path to avoid fault zones, fishing zones, anchoring areas, and other dangers. A marine survey is key to the determine the safest route.



- **Who owns the cables?**
  - Cables were traditionally owned by telecom carriers who would form a consortium of all parties interested in using the cable (eg Japan-US built in 2001 with 24 consortium parties).
  - In the late 1990s, a lot of entrepreneurial companies built many private cables but struggled when the dot.com bubble burst in 2000 (Global Crossing, Flag, TGN).
  - Both the consortium and private cable models still exist today, but one of the biggest changes in the past few years is the investment by Content Providers in new cables.
  - Content providers such as Google, Facebook, Microsoft, and Amazon are major investors in new cables. Ongoing massive bandwidth growth between data centres means owning new submarine cables makes sense for these companies.

Introduction to Subsea

Marine Operations



The world is not flat… nor is the seabed…

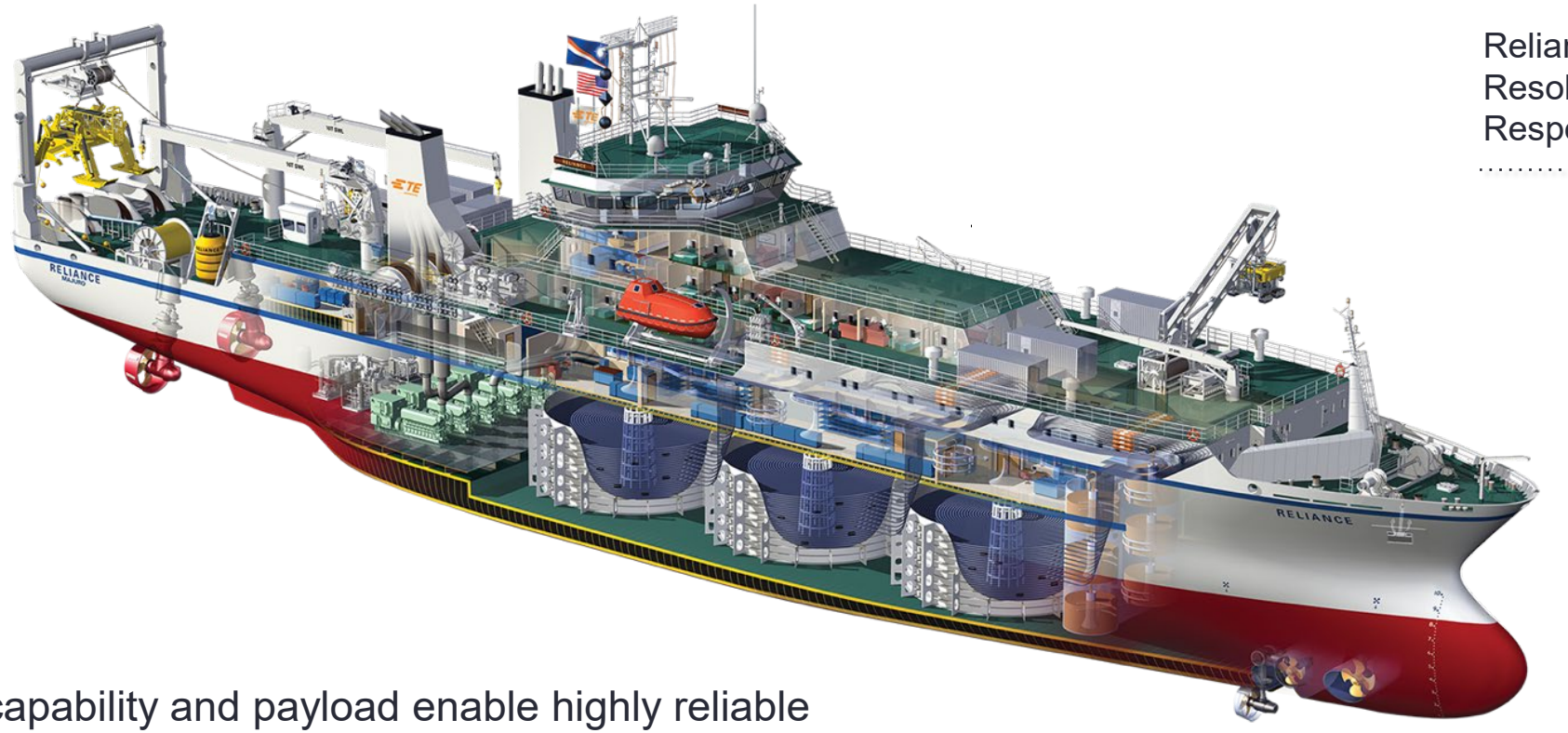
Sources: Google Maps; Nasa

Introduction to Subsea

SubCom Fleet: Reliance Class

RELIANCE CLASS SHIPS

Reliance	Decisive
Resolute	Dependable
Responder	Durable

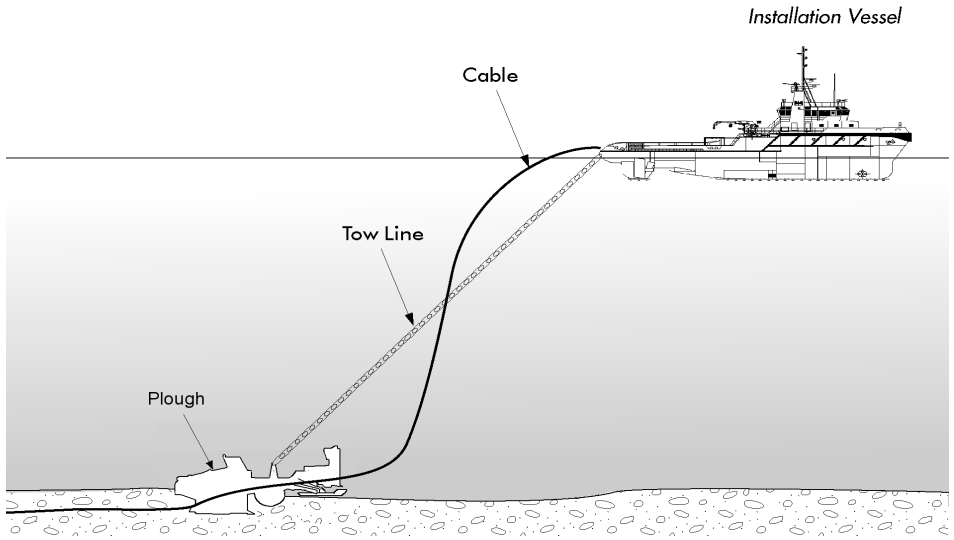


- Size, capability and payload enable highly reliable cable installation and maintenance services
- Using dynamic positioning technology, these ships can maintain static position for lay and repair operations, under most severe conditions, and operate with improved fuel economy and reduced crews
- 140m long, ½ the size of the Titanic

Introduction to Subsea

Cable Burial

- **Primary tool for burial is a plough deployed from a main lay vessel**
- **Burial is normally necessary for all submerged plant laid in water depths of less than 1000m**
- **New generation ploughs can bury up to >3m where required**



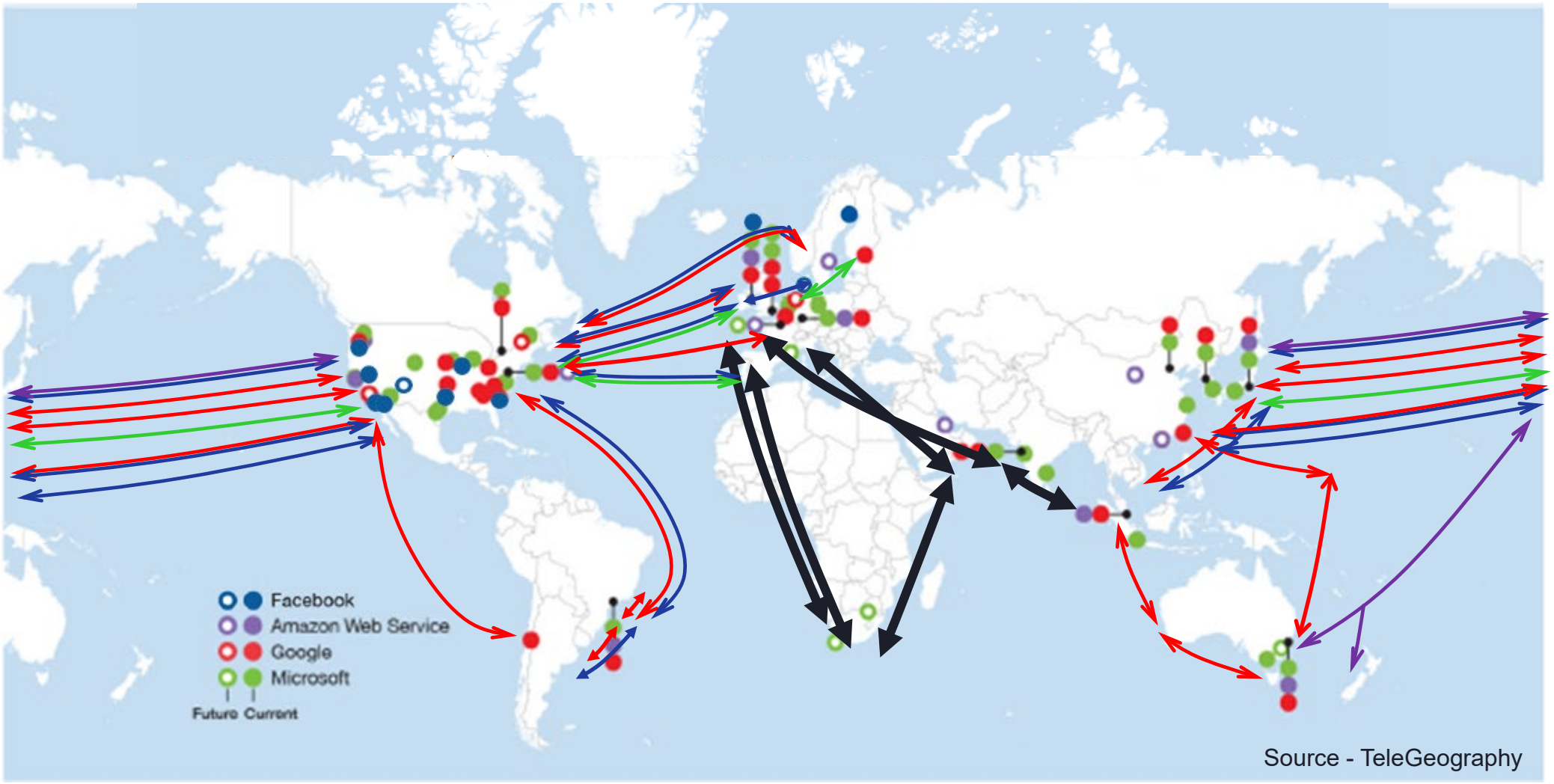
Introduction to Subsea

Content Providers' Investments by 2015

Source - TeleGeography

Introduction to Subsea

Content Providers' Investments - recent



Source - TeleGeography

Introduction to Subsea

2Africa

- **2Africa project announced in 2020**
- **>45,000kms**
- **46 landings, 33 countries, 3 continents**
- **3x total network capacity of cables to Africa today**
- **Intended to reach 3 billion people (36% global population)**
- **Consortium of 8 companies**

China Mobile International

FACEBOOK

MTN GlobalConnect

orange

stc

telecomegypt

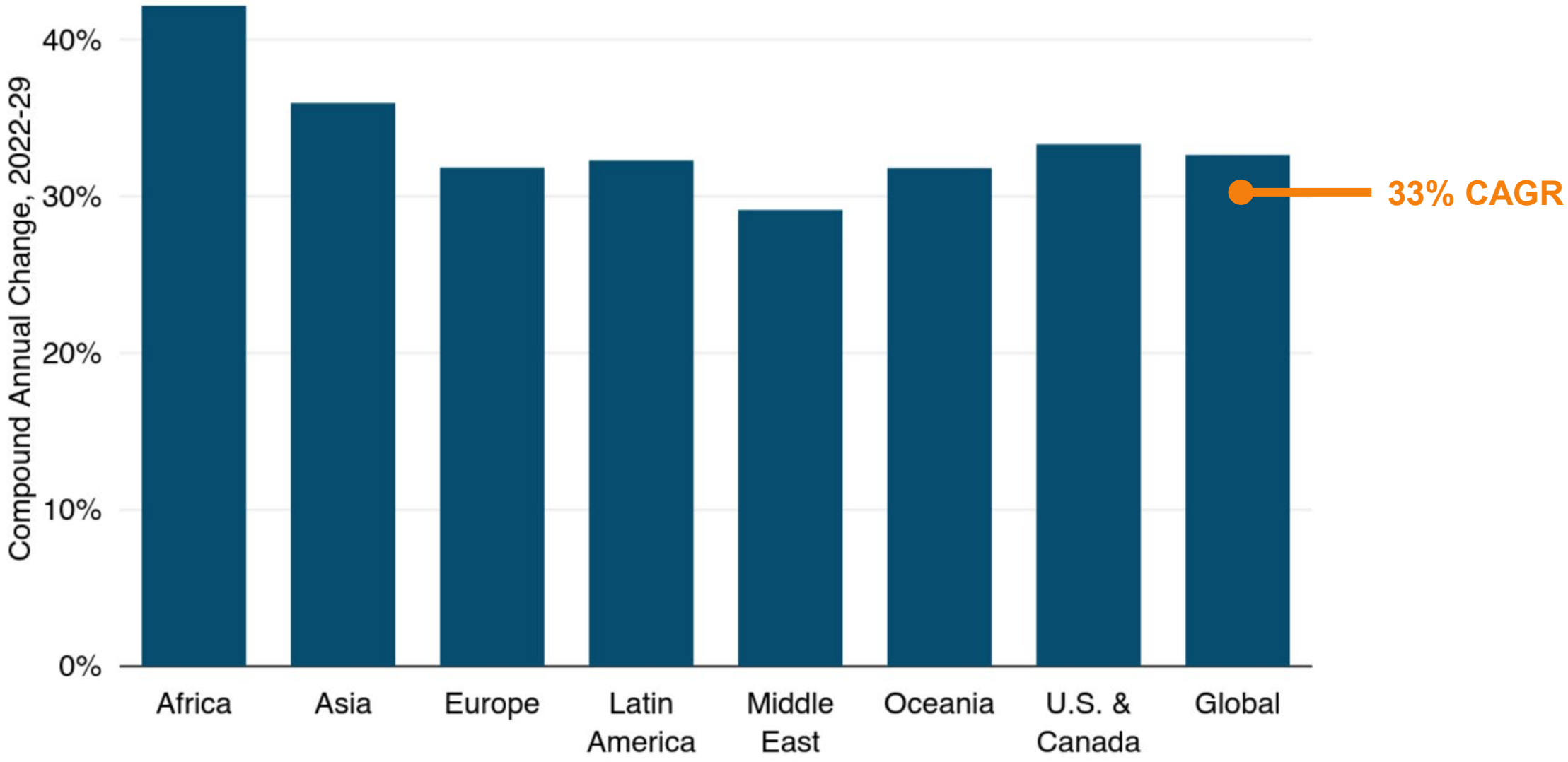
vodafone

WIOCC

Africa's Hyperscale Infrastructure

Permitting (e.g. Jemen, Libya)

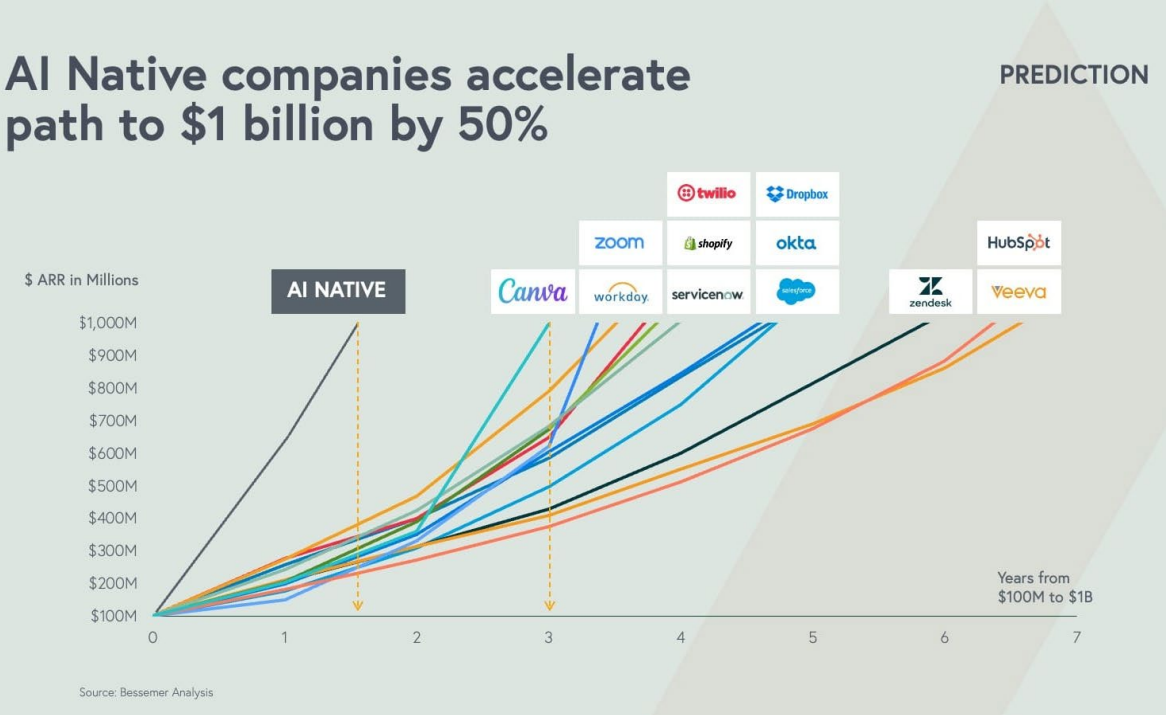
Used International Bandwidth Growth by Region



AI is growing faster than cloud

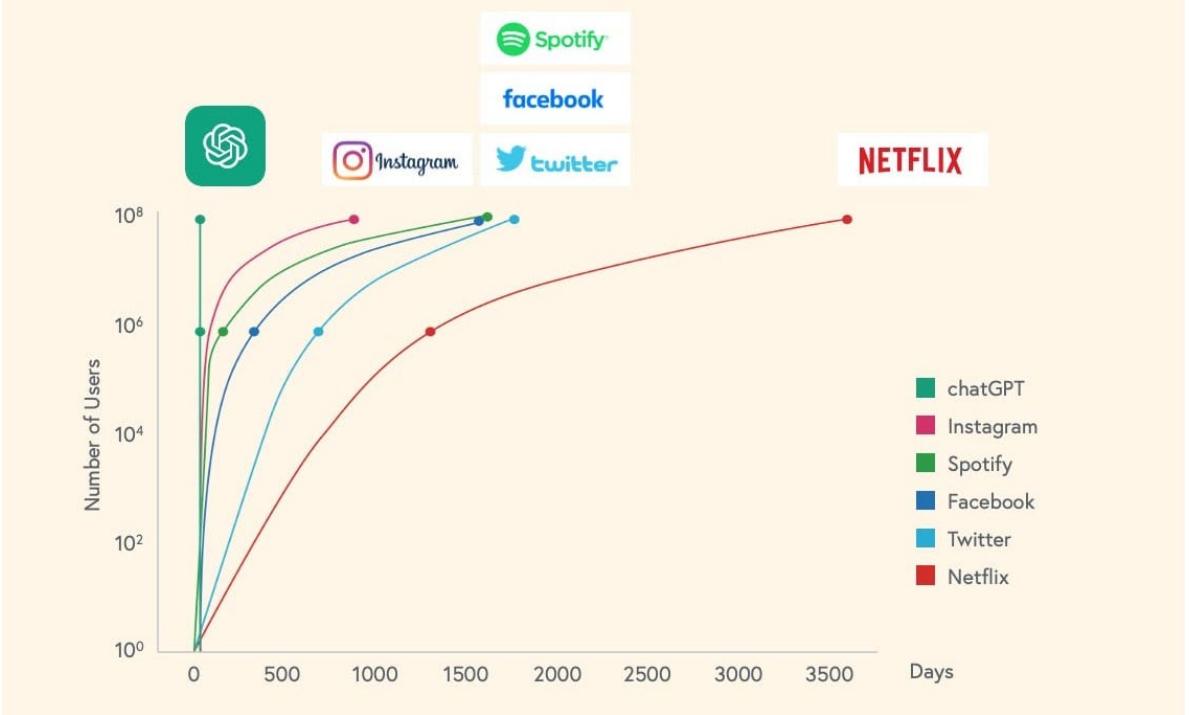
Tangible use cases and products compared to previous hypes (like NFT, Blockchain etc.)

AI versus Cloud



AI companies are predicted to reach $1B ARR 50% faster than cloud counterparts

Rapid Adoption of AI Applications



ChatGPT is fastest growing consumer application in history with 100 million active users in 2 months

AI is rapidly redefining how we interact … and that will impact the network

https://www.bvp.com/atlas/state-of-the-cloud-2023#Accelerating-value-creation-in-the-cloud-economy

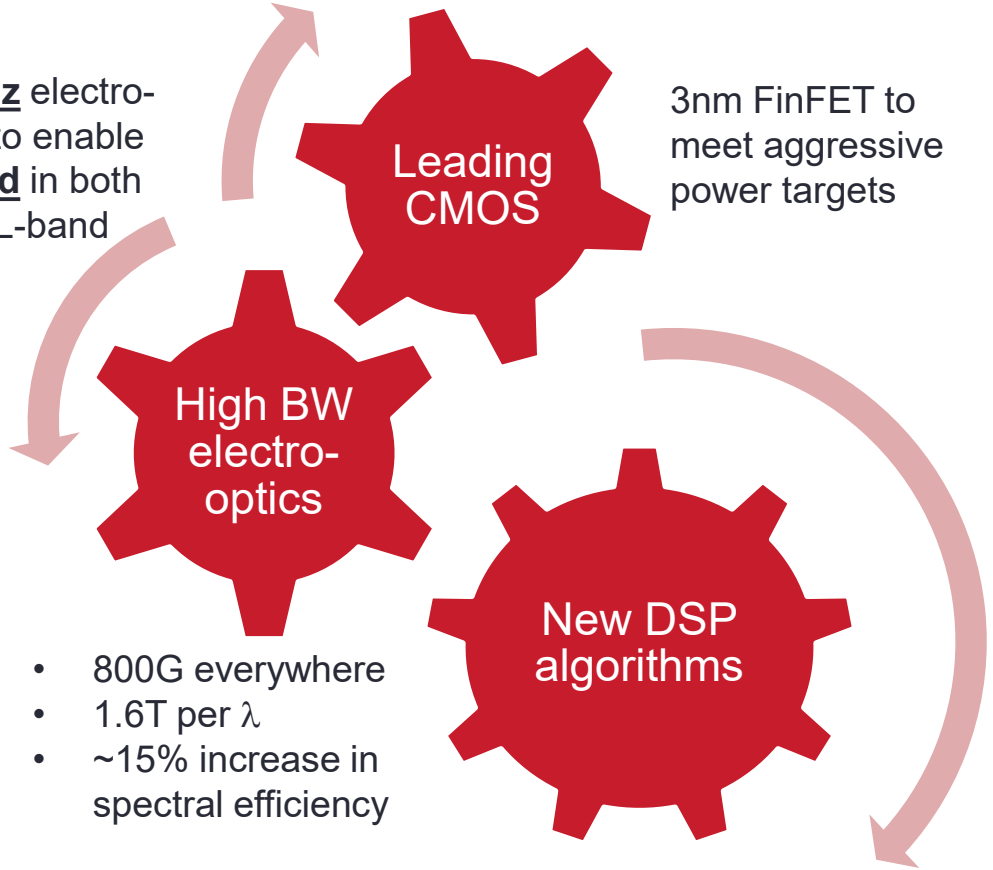
Source: UBS Research

Challenges – Meeting the Growth expectations

- Shannon limit and the current wet plant design doesn’t have lots of growth potential
- Wet plant: SDM, MCF, C+L
- Fit for purpose design with increased standardization and focus on lowest unit cost
- Sustainability issues
- Encouraging entrepreneurs and carriers – to participate in cable developments

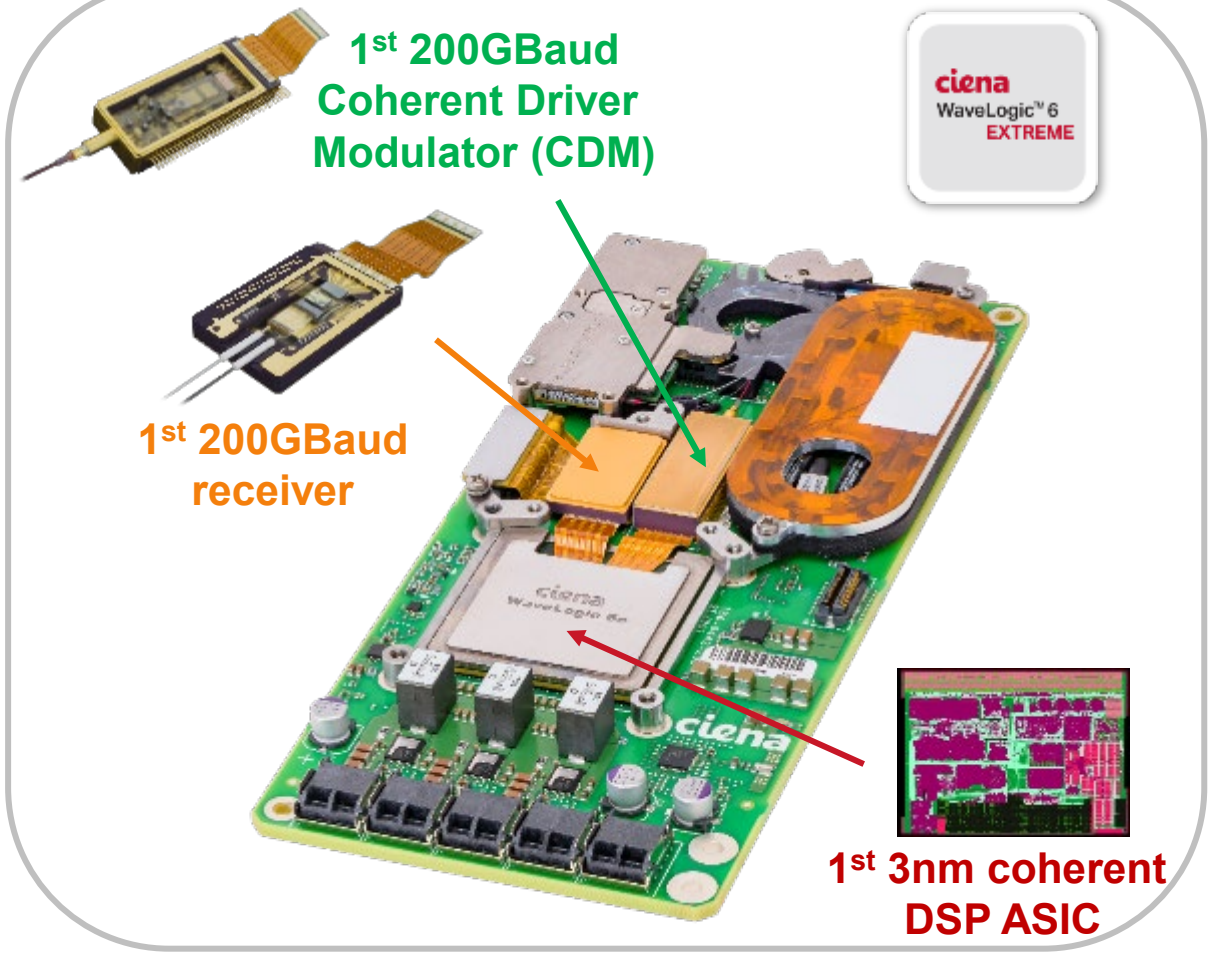
WaveLogic 6 Extreme design: World-first 1.6T, ubiquitous 800G, 50% reduction in power and space, 15%+ increase in fiber capacity

100GHz electro-optics to enable **200Gbd** in both C and L-band



3nm FinFET to meet aggressive power targets

- 800G everywhere
- 1.6T per λ
- ~15% increase in spectral efficiency



Simplest adoption with support in existing platforms, within same thermal envelope

Dramatic Reductions in Modem Space and Power

1995

40Gb/s was 16 wavelengths of 2.5Gb/s in 1 telco bay so 400Gb/s required 10 bays

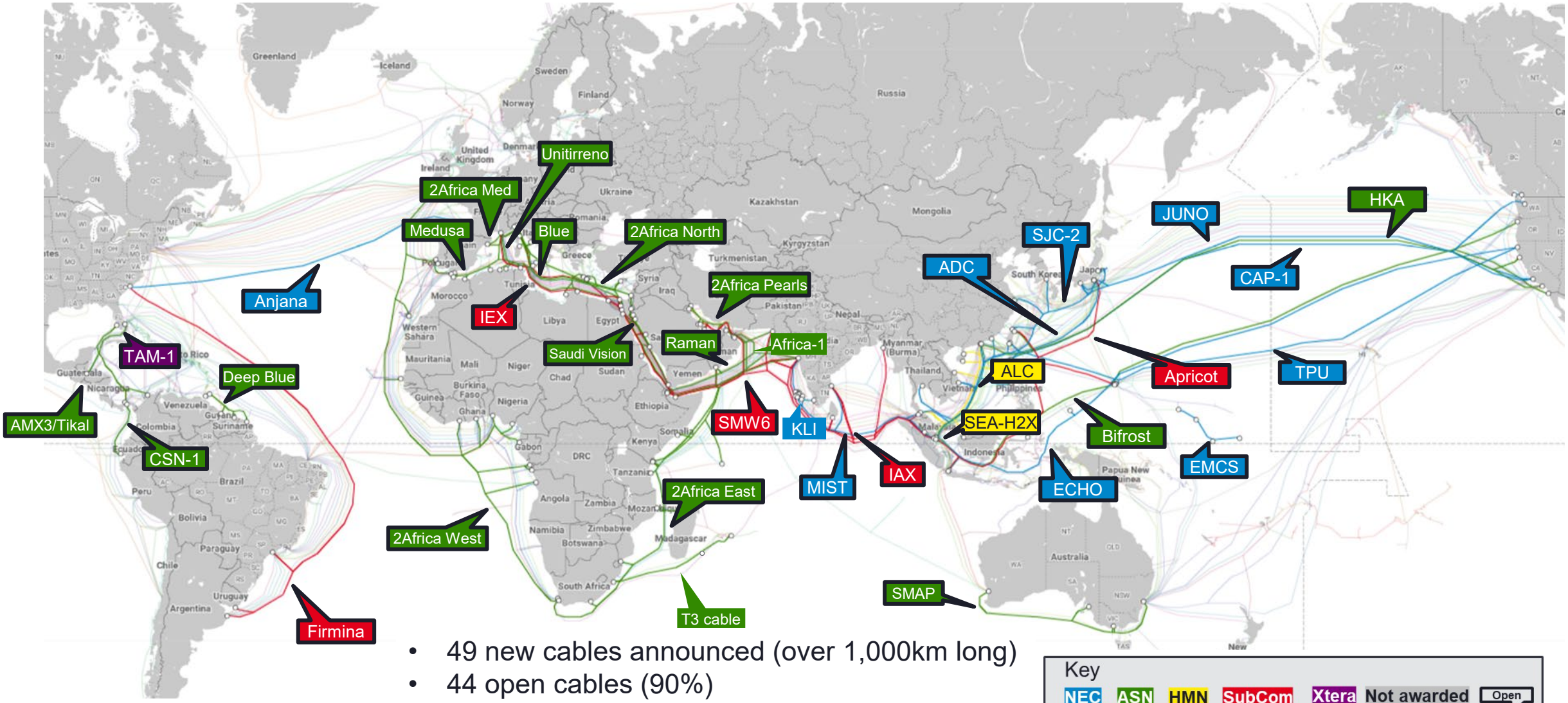
2020

3.2Tb/s+ of submarine network capacity in 2RU (Rack Units)

2024

6.4Tb/s+ of submarine network capacity in 2RU (Rack Units)

Publicly Announced Submarine Cable Landscape (36 CIF)



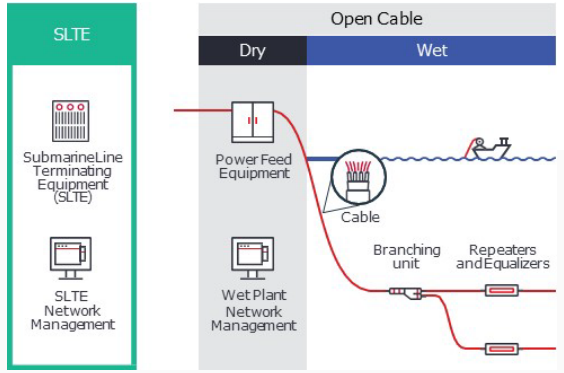
- 49 new cables announced (over 1,000km long)
- 44 open cables (90%)
- 36 contract in force

Industry Trends

Submarine Cable Industry trends

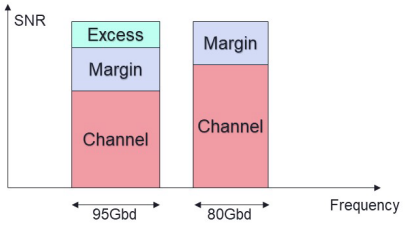
Open Cables

- >90% of new cables are Open Cables
- Standardisation of an Open Cable Model has been the challenge



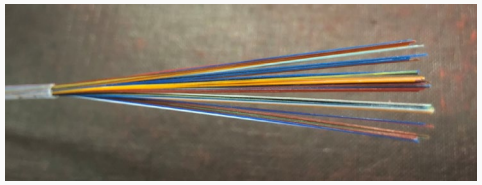
Programmable 800G Modems

- Single channel line rates of 400G over any distance on uncompensated
- Multi-baud rate up to 95Gbaud to maximise spectral efficiency
- Used to trade any surplus margin for additional capacity



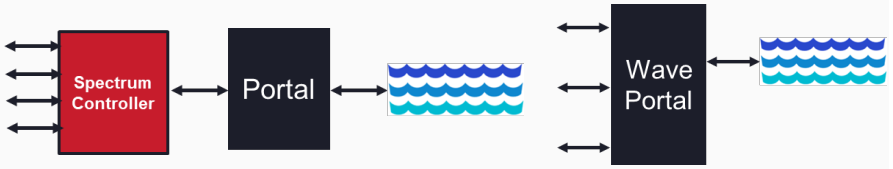
SDM Cables

- More fibre pairs (12fp & 16fp -> 24fp) to increase cable capacity
- 0.5 Petabit/s cables a reality



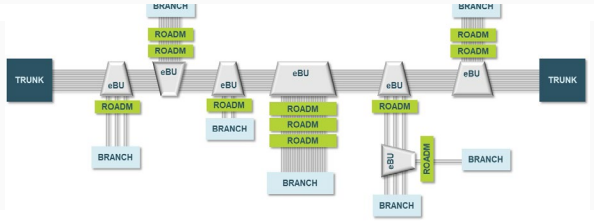
Spectrum Sharing

- Procuring & lighting less than 1 fibre pair
- Simple concept, complex in practice



Wet WSS ROADM

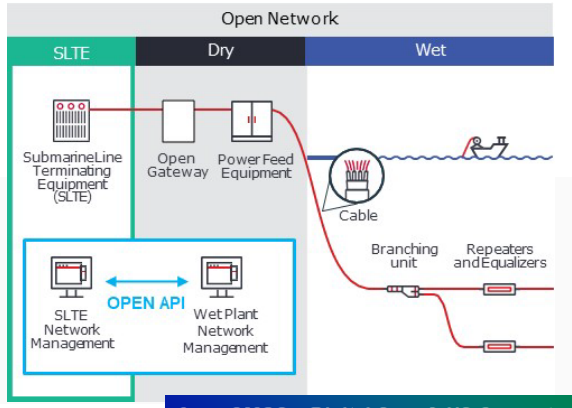
- Branching units with WSS ROADMs in deployment
- Increasing network flexibility in wet plant infrastructure



Submarine Cable Industry trends

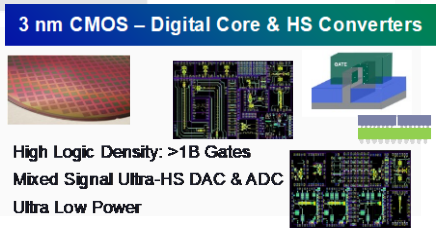
Open Networks

- Evolution from Open Cables to Open Networks
- Open APIs on wet plant NMS to allow integration with SLTE NMS



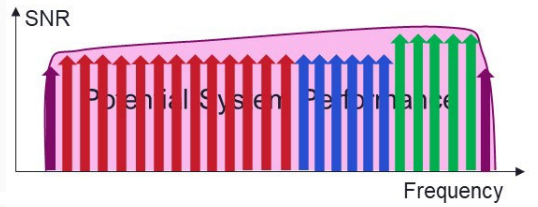
>1Tb/s high baud modems

- Target up to 1.6Tb/s with 3nm CMOS – 800G anywhere on submarine
- Spectral efficiency improvement and fewer modems, reducing cost/bit



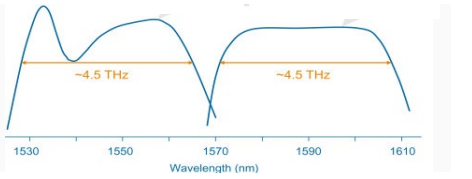
Automation

- For validation and acceptance of open systems – optimiser tool
- Maximum capacity from upshifting channels with margin



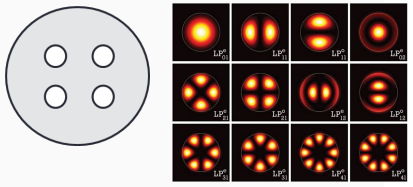
C&L band

- C&L terrestrial backhaul to satisfy backhaul demand with SDM systems
- Regen optimization can reduce overall system cost significantly



Multi-core & multi-mode fibre

- Increase capacity through single fibre
- Multi-core fibre (MCF) first stage, 2-4 cores

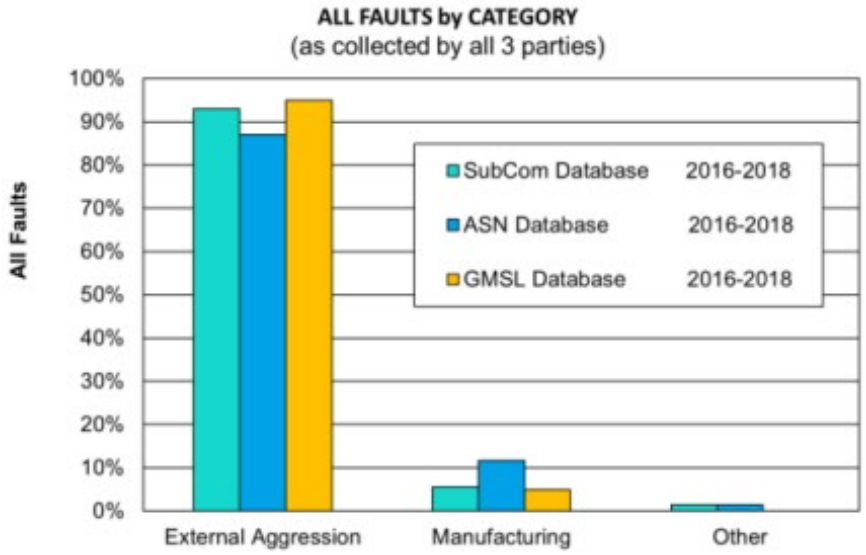


Challenges & Opportunities

Introduction to Subsea

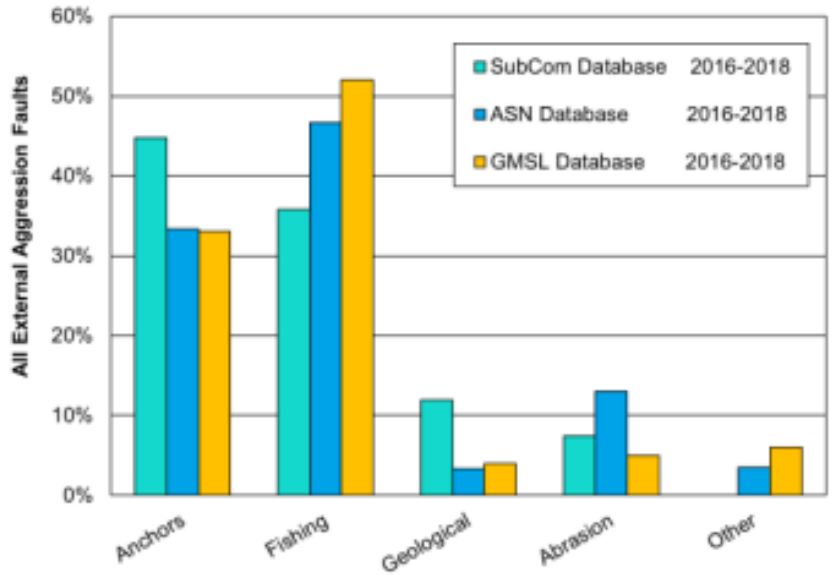
Cable breaks

- **On average ~100 cable breaks/year**



Overall Causes of Cable Failure

- ~90% caused by External Aggression



External Aggression Faults for all Water Depths

- ~80% caused by Anchors & Fishing
- 75% in water depths <100m

Source: SubOptic 2019 Global Trends in submarine cable faults 2019 update, Kordahi et al

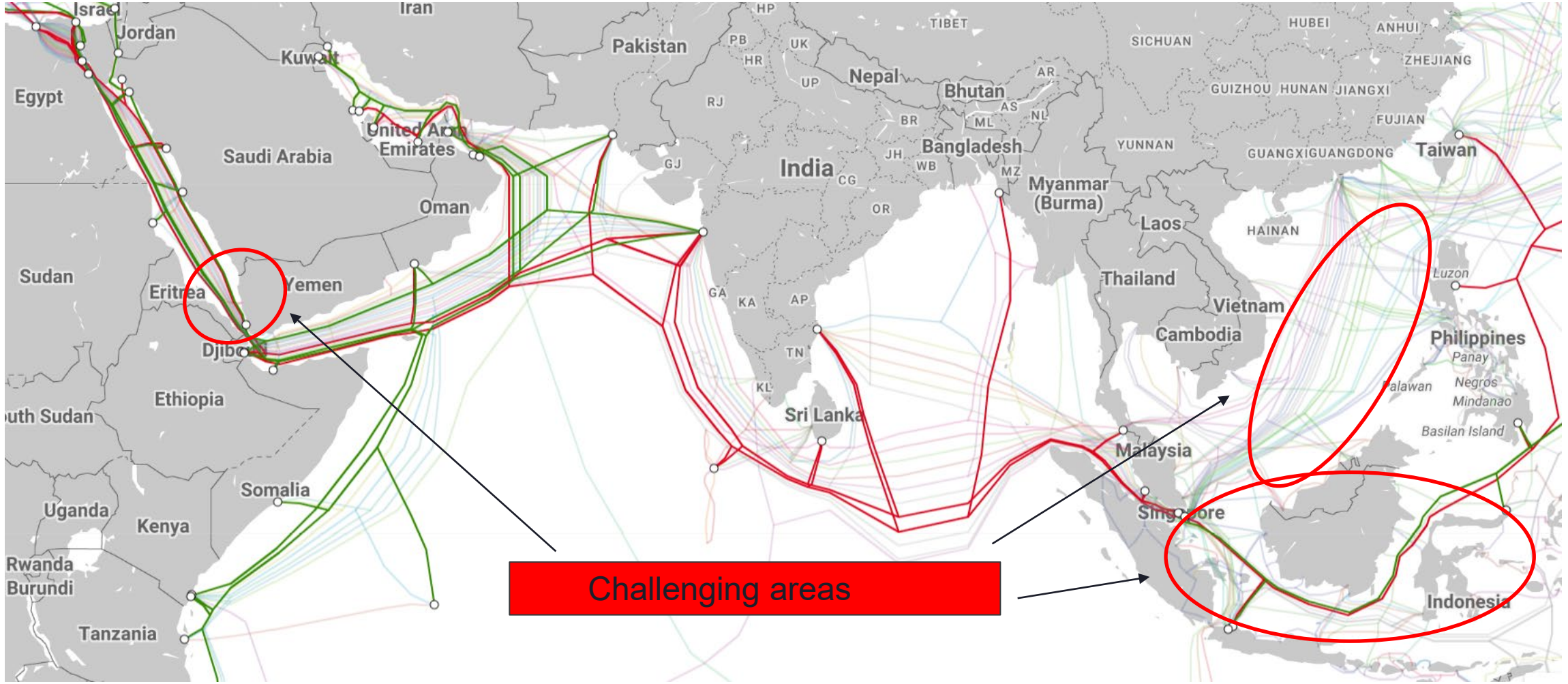
Challenges – Providing continuity of service

- Increasingly congested seabed
- Build in restoration over terrestrial routes
- Environmental considerations and power consumption

Challenges – Regulatory and Permitting

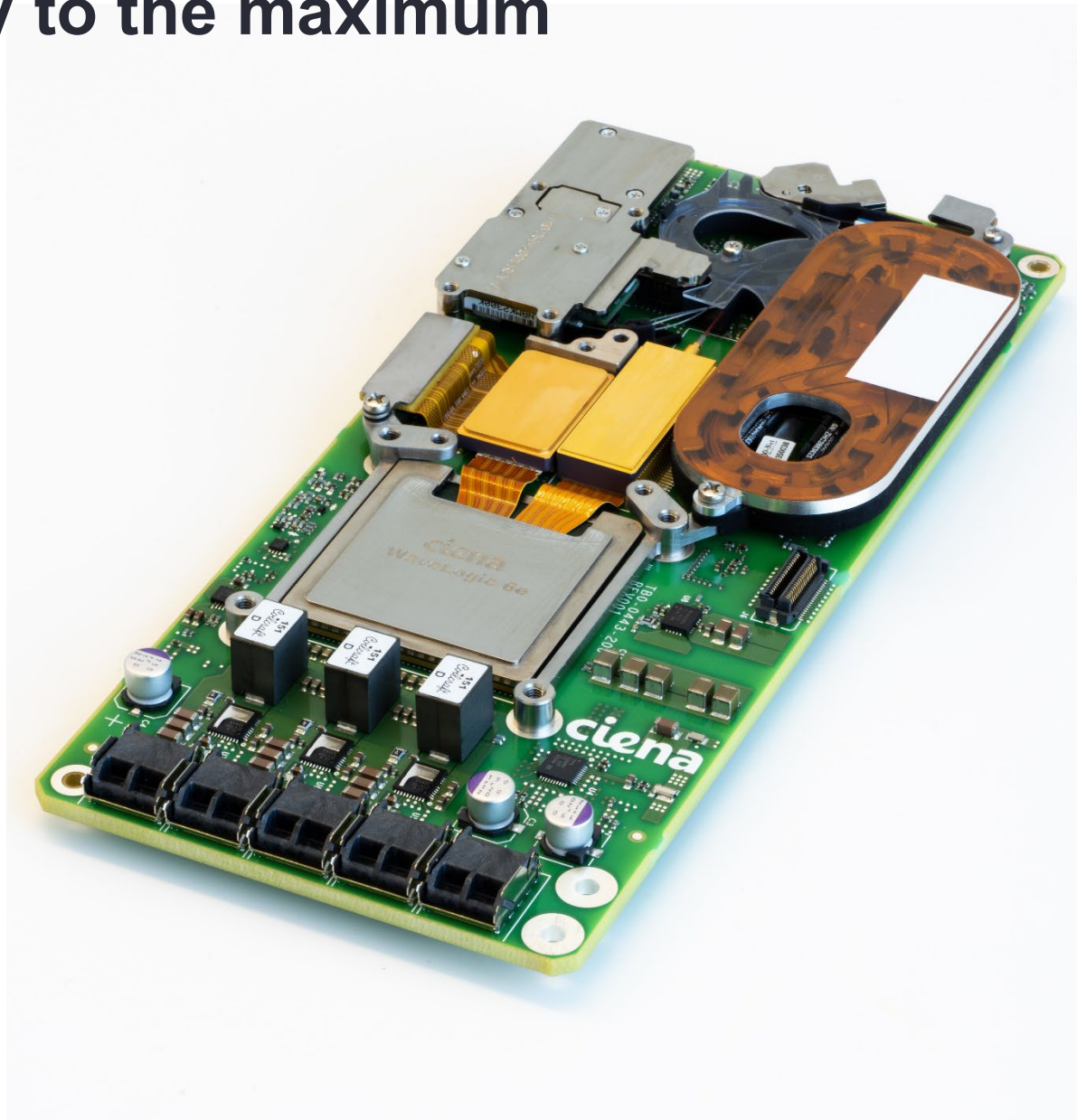
- Geopolitics
- Increased MDA
- Critical Infrastructure Designation
- Cabotage
- Cable Corridors

Several new systems experiencing construction delay



Opportunities – Exploit technology to the maximum

- Optimize ultimate capacity based on SDM, ROADM's and C&L Band repeaters to reduce cost per bit
- Improve cost, space requirement and environmental impact through next gen SLTE and transponder
- Consider alternative benefits to be derived from the asset: A source of scientific data or an early warning system.
- Growing requirements add complexity and require more automation
- Improve standardization: cable types; spares management and repairs
- Provide visibility across networks – rather than a cable



Our global submarine cable network industry is experiencing rapid and constant change that presents both challenges and opportunities

More collaboration and partnerships between stakeholders is critical for financial success as well as improving the socioeconomic state of people

Key Takeaways

1	Significant global demand growth
2	Geopolitical, legislative, security and environmental factors increasingly challenging
3	Increased collaboration within industry required

Thank you

Any questions?