

Mythbusters IV: Resurrection Busting Submarine Cable Myths

Name: Tim Stronge & Alan Mauldin Company: TeleGeography



Presenter Profile





Tim and Alan are trained mythbusters.

Do NOT attempt to test any of these dangerous myths at home.

Name: Tim Stronge Title: VP-Research Email: tstronge@telegeography.com Alan Mauldin Research Director amauldin@telegeography.com







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Industry myths to be tested



- \$10 trillion in financial transactions flows over submarine cables each day.
- Geopolitical conflict between China and the U.S. has caused the two countries' networks to disconnect.
- The lifespan of a cable is 25 years.
- Submarine cables account for over 99% of intercontinental data traffic.
- "The greatest shortcoming of the human race is our inability to understand the exponential function."
- The industry's current practices will be enough to accommodate future capacity requirements.





- The Myth: \$10 trillion in financial transactions flows over submarine cables each day.
- Conclusion: ???
- Status:



The New York Times

Russian Ships Near Data Cables Are Too Close for U.S. Comfort

🛱 Give this article 🔗 🗍 🖵 471

By David E. Sanger and Eric Schmitt Oct. 25, 2015

The role of the cables is more important than ever before. They carry global business worth more than \$10 trillion a day, including from financial institutions that settle transactions on them every second. Any significant disruption would cut the flow of capital. The cables also carry more than 95 percent of daily communications.



 \equiv TIME

The Digital Cloud Is Underwater-and Vulnerable

BY KARL VICK AND EMILY BARONE OCTOBER 6, 2016 7:41 AM EDT

I t was a symbol of progress, the first transatlantic telegraph cable paid out from the deck of a ship between Telegraph Field in Ireland and Heart's Content, Newfoundland. It took four years to lay, and it functioned for three weeks in 1858 before breaking. Today there are 312 undersea cables, all wrapped around glass fiber as thin as a human hair. They carry 99% of the world's intercontinental data, including business transactions worth \$10 trillion a day. And one is being repaired about every third day.

It's usually a fish trawler or anchor at fault, though in 2015 the Pentagon closely watched Russian submarines stalking cable routes, and also a spy ship equipped with submersibles capable of reaching the cables. Close to shore, the lines are reinforced to the thickness of a soda can and buried in trenches made by an undersea digger. But deep at sea they lie right out on the seafloor, about as thick as a garden hose and usually near cables laid earlier, to save the cost of surveying a new route.





STATEMENT OF COMMISSIONER JESSICA ROSENWORCEL

Re: Improving Outage Reporting for Submarine Cables and Enhanced Submarine Cable Outage Data, GN Docket No. 15-206, Report and Order.

There are roughly 300 submarine cables buried in the coldest and darkest depths of our oceans. We may not see them but we rely on them daily.

Submarine cables are an essential part of the global economy. They are responsible for \$10

trillion worth of transactional value every day. That is mo healthcare annually. It's greater than the Gross Domestic combined. It's a big deal.

FCC • July 2016



DECEMBER 1, 2017

Undersea Cables: Indispensable,

insecure

We must do more to protect the indispensable yet insecure internet infrastructure provided by undersea cables, urges Rishi Sunak MP in a new report published by Policy Exchange, *Undersea Cables: Indispensable, insecure.*

97% of global communications and \$10 trillion in daily financial transactions are transmitted not by satellites in the skies, but by cables lying deep beneath the ocean. Undersea cables are the indispensable infrastructure of our time, essential to our modern life and digital economy, yet they are inadequately protected and highly vulnerable to attack at sea and on land, from both hostile states and terrorists.





- 1. Do financial institutions generally use submarine cables for transactions?
 - Answer: yes
 - Source: TeleGeography interviews
- 2. Is there \$10 trillion / day globally in financial transactions?
 - Let's examine SWIFT payments as an example
 - In 2004, 10m messages/day = \$5 trillion / day.
 - Implies average \$500k per message.
 - In December 2022, 44.8m messages / day
 - At \$500k/message, implies \$22.4 trillion / day



But wait ... are these all intra-Europe?



- SWIFT data centers
 - Zoeterwoude, Netherlands
 - Diessenhofen, Switzerland
 - Culpeper, Virginia, United States
- Fully mirrored in real-time
- Preliminary conclusion
 - Trans-Atlantic mirroring
 - Even if avg. transaction value has fallen, highly likely that SWIFT, alone, accounts for >\$10 trillion/day



Fünf der sieben Etagen des Swift-Rechenzentrums in Diessenhofen liegen unterirdisch.

10

\$10 trillion a day myth

Nerd moment: what does one of these messages look like?

- Switching to ISO 20022 format
- Simply an XML document
- Sample cross-border message = 2 KB
- How much traffic would that generate?
 - 2 KB x 44.8M messages per day
 - Assume away encryption, large messages, no traffic peaks
 - => Would require only 8.3 Mbps!

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How much is \$10 trillion? Let's be literal.



- 1 one dollar bill height = 0.10922 mm
- 1 meter of dollar bills =







How much is \$10 trillion? Let's be literal.









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Let's be literal.



Moon ~ 384k km = \$3.5 trillion

GEO satellites ~36k km

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Can we fit \$10 trillion in cables? (Being stupidly literal.)

Combined length of submarine cables = 1.9 million km

\$10 trillion stack = 1.1 million km

Moon ~ 384k km

Earth









- The Myth: \$10 trillion in financial transactions flows over submarine cables each day.
- Conclusion: Most international financial transactions run over cables. The daily value likely exceeds \$10 trillion.
- Status:







- The Myth: Geopolitical conflict between China and the U.S. has caused the two countries' networks to disconnect.
- Conclusion: ???
- Status:





Before the FEDERAL COMMUNICATIONS COMMISSION Wa

In the Matter of

GU HOLDINGS INC., EDGE CABLE HOLDINGS USA, LLC and PACIFIC DATA COMMUNICATION CO. LTD.

Application for a License to Construct, and Operate an Undersea Fiber Optic C Connecting the United States, Hong Kc Taiwan, and the Philippines





BtoBE







HKA







Planned trans-Pacific cables





Disconnect tests overview



Test	Outcome
Direct physical disconnection	
Indirect physical disconnection	?
BGP disconnection	?
Network presence disconnection	?
Layer 2/3 network links disconnection	?



Indirect physical connection: planned intra-Asia cables





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Chinese claims in South China Sea causing headaches



Chinese Claimed Territory vs. Existing Cables



Routing of Planned Apricot Cable



Sources: Cable data: TeleGeography. Geographic boundary data: Greg Poling, The South China Sea in Focus: Clarifying the Limits of Maritime Dispute (csis.org/analysis/south-china-sea-focus)

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	Layer #	Layer Name	Example	
	7	Application	End user layer	
	6	Presentation		
	5	Session		
	4	Transport	TCP/IP, BGP	DE
	3	Network	Packets (IP)	DE HERL
	2	Data Link	Ethernet frames	NARL
	1	Physical	Cables	



Some actions did target non-physical areas of network stack



- What is a U.S. Section 214?
 - FCC: "Any person or entity that seeks to provide U.S.-international common carrier service ... must obtain prior Commission approval pursuant to Section 214 of the Communications Act of 1934"
 - Designed to protect against anti-competitive behavior by foreign carriers
 - Recent rulings have focused on national security concerns, however
- Timeline for major withdrawals
 - July 2018 China Mobile's 7-year-old Section 214 application denied
 - November 2021 China Telecom's Section 214 authority revoked
 - February 2022 China Unicom's Section 214 authority revoked
- What does this actually do?
 - Emphasis on "common carrier":
 - No general offerings on standardized terms and conditions allowed
 - Private carrier services still allowed:
 - Offerings on a limited basis to specific customers on an individualized, contractual basis



Layer 4 arguments sometimes used to make policy on Layer 1



Before the FEDERAL COMMUNICATIONS COMMISSION Washington, D.C. 20554

In the Matter of

ARCOS-1 USA, INC. A.SURNET, INC.

File No. SCL-MOD-20210928-0

Application for a Modification to Cable Landing License

Recommendation of the Committee for the Assessment o Participation in the U.S. Telecommunications Services to Deny the Application traffic, data, and communications, and create national security risks of espionage, theft, and sabotage by foreign adversaries.³⁵ Foreign adversaries and telecommunication providers subject to their direction or control (like ETECSA) can use BGP vulnerabilities to gain access to sensitive data and communications. For example, when the FCC revoked China Telecom Americas' ("CTA") section 214 license, the record showed that BGP vulnerabilities facilitated CTA's misrouting of U.S. traffic to the PRC on numerous occasions between 2010 and 2019, and thus provided a foreign adversary with opportunities to disrupt, capture, examine, and alter U.S. traffic.³⁶ Similarly, Russian telecommunications providers have hijacked and redirected traffic by exploiting BGP vulnerabilities.³⁷ ETECSA could also take advantage of these vulnerabilities to cause BGP route leaks, leading traffic not destined for Cuba to be misrouted over Segment 26 and into the Cuban government's hands.



SUBOPTIC Bangkok 2023	

A few sample rows from a BGP table



Arteria Networks

- An ISP uses border gateway protocol (BGP) routing tables to announce to the rest of the internet how to reach its IP addresses.
- In this example, Arteria Networks gives access to its 1.0.24.0/23 address range via just 2 direct adjacencies: AS 6939 (Hurricane Electric) and AS 2914 (NTT)
- BGP tables don't show volume of traffic over AS-to-AS paths, or physically where those handoffs occur



U.S.-China direct BGP adjacencies over time





U.S. Networks Presence - 2019

Sim

Notes: Circles scaled logarithmically by number of U.S.-owned networks in a city. Sources: TeleGeography data and PeeringDB.com

U.S. Networks Presence - 2023

2mil

Notes: Circles scaled logarithmically by number of U.S.-owned networks in a city. Sources: TeleGeography data and PeeringDB.com

Notes: Circles scaled logarithmically by number of China-owned networks in a city. Sources: TeleGeography data and PeeringDB.com

Chinese Networks Presence - 2023

Notes: Circles scaled logarithmically by number of China-owned networks in a city. Sources: TeleGeography data and PeeringDB.com

- China-owned networks growth in points of presence (PoPs) 2019-2023
 - In U.S. = 47% ∆
 - In China = 215%
 - In rest of world = 115%
- U.S.-owned networks growth in points of presence (PoPs) 2019-2023
 - In U.S. = 43% Δ
 - In China = 55%
 - In rest of world = 49%
- Conclusions:
 - Chilled growth of Chinese networks in United States ... but still growth
 - Faster growth of U.S. networks in China than in rest of world!
China/U.S. network disconnect myth

International Capacity (Layer 2 and 3 Circuits)





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Disconnect tests summary



Test	Outcome
Direct physical disconnection	
Indirect physical disconnection	×
BGP disconnection	×
Network presence disconnection	×
Layer 2/3 network links disconnection	×

China/U.S. network disconnect myth



- The Myth: Geopolitical conflict between China and the U.S. has caused the two countries' networks to disconnect.
- Conclusion: Tensions no longer allow for new end-to-end submarine cable connections. But, to date, overall network connectivity has been unchanged.



The cable lifespan myth



- The Myth: The lifespan of a submarine cable is 25 years.
- Conclusion: ???
- Status:





- Submarine cables are engineered to have a minimum life of 25 years.
 - Wet plant components are designed to have a specified failure rate during a 25year period.
- Warranties, permits, and landing licenses commonly have a length of 25 years.

Sample FCC Cable Landing License

Commission, Washington, D.C. 20554, in writing, within thirty (30) days of the date the cable is placed into service, of the date the cable was placed into service. The cable landing license shall expire twenty-five (25) years from the in-service date, unless renewed or extended upon proper application. Upon expiration, all rights granted under the license shall be terminated.



What about the economic lifespan?



- The economic life of a cable depends on a system's revenues exceeding costs.
 - This point may be reached before or after a cable reaches its potential capacity.
 - Economic lifespan varies by cable.
- Factors influencing a cable's economic lifespan:
 - Cable capacity and demand growth
 - Competition and rates of price erosion
 - Faults
 - Recurring revenues
- Cables may effectively reach their end of economic life, but remain in service for reasons related to route diversity, corporate strategy, or national security.



Recent cable lifespan trends



- Technical design life ≠ economic life ≠ actual life
- For repeatered cables retired from 2010-2022, the average lifespan was 17 years.

Repeatered Cables Retired Since 2010



Cable lifespan myth Nearing the end?



- Active Repeatered Cables 20+ Years of Service 30 25 Years in Service 10 10 20 5 0 Yellow GlobeNet APCN-2 Europe **TGN-Atlantic** Apollo Cross GN-Pacific Maya-1 Am-II KJCN TIS JUS SAC PAC MAC FOG AJC SAFE AC-1 N. & S. PC-1 SAm-1 2 MedNautilus FA-1 EAC-C2C SeaMeWe-3 **AU-East** SAT-3/WASC NAL/RNAL Southern GN-W. Other Trans-Atl Trans-Pac Latam Asia Eu-Asia
- Some of these have already filed license extensions (e.g. Southern Cross, AC-1).
- Some have retirements pending (e.g. JUS, SMW-3)
- Many of these cables will certainly exceed 25 years of service.



Cable lifespan myth

The key to aging gracefully

- Cables built in the late 90s/early 2000s benefited from SLTE advancements to massively boost design capacity (>10x in some cases!).
- Without these advancements, these cables would have been economically obsolete years ago.



Potential Capacity – RFS vs 2022





Earlier retirement in the future?

- Modern cables are realizing higher throughput via more fiber pairs and potentially more cores.
- Once a cable is deployed it can't take advantage of these improvements, limiting its potential capacity beyond initial levels.
- Could relatively new cables become retirement candidates well before 25 years in the next decade?

Fiber Pair Count in Trans-Atlantic Cables







The cable lifespan myth



- The Myth: The lifespan of a submarine cable is 25 years.
- Conclusion: Many aspects of cable design and deployment are based on a 25year lifespan, but actual lifespans vary depending on many factors



• Status:





- The Myth: Submarine cables account for over 99% of intercontinental data traffic.
- Conclusion: ???
- Status:



 The "99% of intercontinental traffic" figure is frequently cited in the press with no source given.

TECH & SCIENCE

International Data

- Also many variations exist:
 - 99% of international
 - 99% of transoceanic
 - 95% of intercontinental

9 9 % 1 N V I S I B L E	EPISODES	ARTICLES	ABOUT ~
ARTICLE BY KURT KOHLSTEDT			
Underwater Cloud: Inside the			
Cables Carrying 99% of			
Trance coanie Data Traffic			
Transoceanic Data Hallic			

Undersea Cables Transport 99 Percent of









- Sometimes, we (TeleGeography) are given as the source.
- Links often go to the FAQ for our submarine cable map

	TeleGeography	
	Submarine Cable Frequently Asked Questions	
lt's h	ard to know exactly how much of all international tra	l Iffic is still carried via satellite, but it's verv small.
Stat	stics released by U.S. Federal Communications Com	mission indicate that satellites account for just
0.37	% of all U.S. international capacity.	

Where does this take us?

The 99% myth

What does the FCC say



Commission CATEGORIA DOREAGE & GATACES		\ast
About the FCC Proceedings & Actions Licensing & Databases Reports & Research News & Even	ts For Consumers	

Home / International

Circuit Status Report

<u>Circuit Status Reports</u>. Under Section 43.82 of the Commission's rules each facility-based carrier engaged in services is require to file a circuit status report. All carriers must file the Circuit Status Reports by March 31 for included in the circuit status report is described in the Circuit Status Manual [csmanual.doc | PDF]. Section a facility-based resellers) to file the report regardless of whether or not they have activated circuits at the year at year-end, they are still required to file a report stating that they do not have any activated circuits.

Most recent data is for 2013, released in 2015.

* 2003 data released 12/23/2004 News Release Report in PDF Format
* 2004 data released 12/22/2005 News Release Report in PDF Format
* 2005 data released 01/19/2007 News Release Report in PDF Format
* 2006 data released 02/19/2008 News Release Report in PDF Format
* 2007 data released 03/17/2009 Statement Report in PDF Format
* 2008 data released 03/31/2010 Statement Report in PDF Format
* 2009 data released 12/21/2010 Statement Report in PDF Format
* 2010 data released 03/30/2012 Statement Report in PDF Format
* 2011 data released 06/19/2013 News Release Report in PDF Format
* 2012 data released 05/14/2014 News Release Report in PDF Format
* 2013 data released 07/16/2015 News Release Report in PDF Format



Other ways to test this myth



Euroconsult, a satellitefocused market research firm, tracks satellite capacity



The increasing dominance of NGSO satellites is also reflected in the supply forecast, with NGSO accounting for ~90 percent of total supply to be added in the next five years. The total global capacity supply (including all orbits) will rapidly expand from 3.7 Tbps in 2020 to 23 Tbps in 2022 and is projected to reach more than 50 Tbps in 2026, as additional constellations enter into service.

Source: Euroconsult, https://www.euroconsult-ec.com/press-release/ngso-constellations-continue-to-gain-momentum-satellite-connectivity-video-market-expected-to-double-over-next-decade/



Satellite bandwidth is indeed booming

Euroconsult Data on Total Satellite Capacity





- Let's use 50 Tbps as our baseline for satellite capacity.
- Caveats:
 - This is total capacity, not intercontinental only.
 - This is capacity, not traffic.
 - This is a forecast for 2026.
 - We're being very generous with our satellite friends.

Source: Euroconsult



Total intercontinental submarine capacity

Potential Intercontinental Submarine Capacity





- Our (TeleGeography's) estimate of potential capacity of existing and planned intercontinental submarine cables is 8,758 Tbps.
- Terrestrial cables carry a small share of Europe-Asia capacity but let's ignore that here.
- Planned cable data only go out to around 2025, not 2026, so not the same as Euroconsult's timeframe





- TeleGeography's potential intercontinental sub cable capacity = 8,758 Tbps
- Euroconsult's total satellite capacity = 50 Tbps
- Submarine cable's share of total intercontinental capacity:

8,758 = 99.43%(50 + 8,758)





- The Myth: Submarine cables account for over 99% of intercontinental data traffic.
- Conclusion: True, but precise calculations are not possible due to lack of data for intercontinental traffic.



The exponential growth myth



- The Myth: "The greatest shortcoming of the human race is our inability to understand the exponential function." Albert Allen Bartlett
- Conclusion: ???
- Status:





- Al Bartlett, a professor at the University of Colorado, USA, is known for delivering an hour-long lecture 1,792 times called "Arithmetic, Population, and Energy: Sustainability 101".
- Focused on exponential growth and the impact on population growth and energy consumption.



Arithmetic, Population, and Energy: Sustainability 101 Source: https://www.youtube.com/watch?v=TBtW51D_q2Q/



- Exponential growth occurs when a quantity increases over time in proportion to its current value.
 - Often viewed as percentage growth or as doubling time.
- Linear growth
 - x: 0, 1, 2, 3, 4
 - y: 1, 4, 7, 10, 13
- Exponential growth
 - x: 0, 1, 2, 3, 4
 - y: 1, 3, 9, 27, 81



Linear versus Exponential Growth



The Bacteria Example

The exponential growth myth

- Assumptions:
 - The number of bacteria in a jar doubles every minute

Why is exponential growth hard to grasp?

11:55am

3% full

- A jar has 1 bacterium at 11:00am and is full at 12:00pm
- Question 1: When is the jar half full?
- Question 2: How full is the jar at 11:55am?



11:59am

50% full







The exponential growth myth Let's test ourselves

- Assumptions:
 - A new cable has 500 Tbps capacity
 - This cable carries 10 Tbps in year 1
 - Demand rises 35% per year
- Question 1: How many years until the cable is 10% full?
 - 3 years
 - 6 years
 - 10 years



Hypothetical Cable





• Question 2: How many years until the cable is 50% full?

-9 years



- 20 years



Hypothetical Cable





- Question 3: How many years until the cable is full?
 - 14 years
 - 17 years
 - -24 years



Hypothetical Cable





The exponential growth myth

Implications for the subsea cable industry



- Cables may seem lightly used for many years (in terms of lit % of potential capacity).
 - This does not mean there is an oversupply.
 - Cables may quickly reach exhaustion once seemingly modest fill rates are reached.
- Long-term demand forecasts are uncertain.
 - Small variances in growth rates can lead to sharply different outcomes in later years.
- Unit prices for bandwidth are experiencing exponential decay.
 - Expanding supply lowers unit costs, which lead to lower capacity prices
 - Easy to underestimate how low future capacity prices will be compared to current rates.





- An 1884 experiment by German psychologist Hermann Ebbinghaus demonstrated the exponential decay of knowledge retention.
- If this seems scary, don't worry.... you'll soon forget all about it.

Ebbinghaus Forgetting Curve



The exponential growth myth



- The Myth: "The greatest shortcoming of the human race is our inability to understand the exponential function." Albert Allen Bartlett
- Conclusion: The exponential function is not intuitive; however, the human race has many shortcomings that can't easily by ranked.
- Status:







- The Myth: The industry's current practices will be enough to accommodate future capacity requirements
- Conclusion: ???
- Status:



Sustainable Capacity Growth Myth	Subection Subect	 View from 2019: Very fast growth across Atlantic
 The Myth: The industry's current practices will be enoug accommodate future capacity requirements Conclusion: No. Something's gotta give 	gh to	 SDM R&D not as advanced
 Status: 		Let's test this again
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Trans-Atlantic growth: the view from 2019





- CAGR 2019-2035 trans-Atlantic
 - 2019 view = 36%

Trans-Atlantic growth: the view from 2023





- CAGR 2019-2035 trans-Atlantic
 - 2019 view = 36%
 - 2023 view = 29%
 - CAGR 2019-2035 trans-Pacific
 - 2019 view = 37%
 - 2023 view = 34%

Trans-Atlantic capacity requirements







This we must estimate


Supply/technology assumptions



2019 model assumptions

- 320 Tbps cables available in 2020
 - 16 FP x 20 Tbps per FP
- 640 Tbps cables by 2023
- 1 Pbps systems by 2025

Relaxed assumptions	

2023 model assumptions

- Cable capacity RFS 2019-24 based on announced design capacity
- 500 Tbps cables by 2024-2030
 - 24 FP x 21 Tbps per FP
- 1 Pbps systems by <u>2030</u>
 - Possibly achievable earlier
 - Some combination of:
 - Higher fiber count (32+)
 - C+L
 - Dualcore/multicore

Trans-Atlantic cable requirements





- This includes some conservative assumptions:
 - Cables built <u>only</u> due to capacity constraints
 - Timing of new cables is in same year as capacity exhaustion; not in advance
 - 1 Pbps cables by 2030
- Chart shows cumulative cables
 - Temporary dip in total cables is due to likely retirements



Estimating global cable requirements



- Near-term (2023-2024)
 - Use planned cable RFS dates
- Long-term (2025-2035)
 - Big routes:
 - Translate capacity demand to cables by assuming Tbps per cable
 - Remember: this is a conservative approach. Assumes building only due to capacity constraints, and just in time to meet demand.
 - Smaller routes:
 - Simplistic assumption of 1:1 replacement on 27th anniversary
 - Forecasts in outer years are very uncertain!



Global cable requirements





- Shows cumulative cables over time
- Excludes cables built before 1996



Global cable length requirements





- Shows cumulative cables over time
- Excludes cables built before 1996
- Temporary dip due to anticipated retirements on major routes



Global cable length added each year









- The Myth: The industry's current practices will be enough to accommodate future capacity requirements
- Conclusion: Technological developments on the supply side + slight slowdown on the demand side = more sustainable environment. (But still lots of uncertainty in outer years.)





Review of industry myths

- \$10 trillion in financial transactions flows over submarine cables ea
- Geopolitical conflict between China and the U.S. has caused the two country networks to disconnect. BUSTED
- The lifespan of a cable is 25 years.
- Submarine cables account for over 99% of intercontinental data traffic
- "The greatest shortcoming of the man race is our inability to understand the exponential function. PI AUSIBLE
- The industry's current oractices will be enough to accommodate future capacity requirements



BUSTEL





Or, sorry that happened to you



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